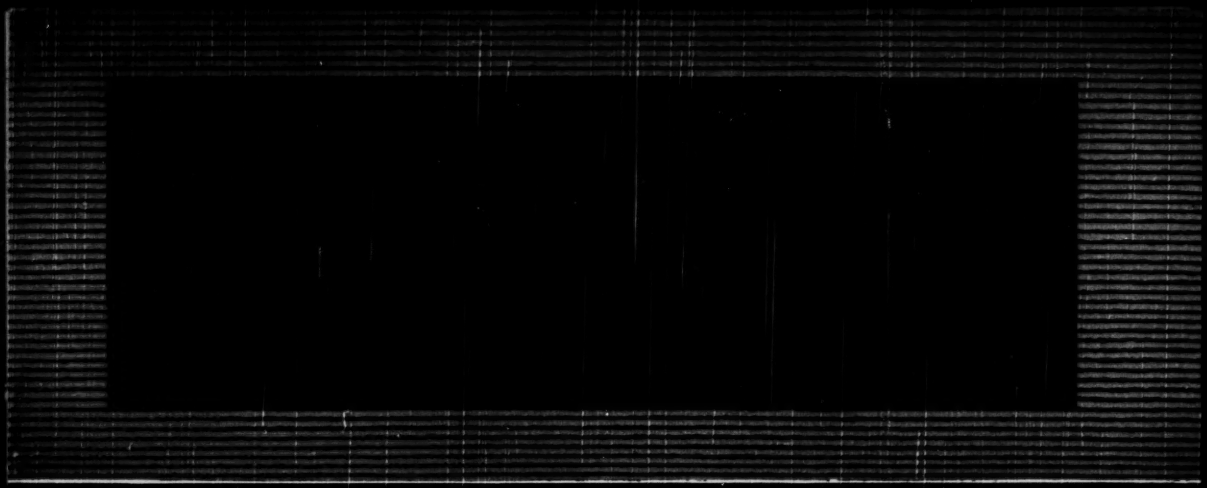


· FEBRUARY 1950 ·

L. Prandtl—A Tribute in Honor of His Seventy-Fifth Birthday 116

Guarding Apprenticeship—Our Priceless Heritage . *D. F. Pratt* 117

Differentiating Characteristics of an Engineering Curriculum . . . . . *S. C. Hollister* 122

Instrument Engineering—Its Growth and Promise in Process-Control Problems . . *G. S. Brown and D. P. Campbell* 124

The Outlook for Ceramics in Gas Turbines . . . . . *W. H. Duckworth and I. E. Campbell* 128

Housings and Spindles for Antifriction Bearings . . *H. L. Blood* 131

Selecting Antifriction Bearings for Machine Tools *J. H. Baninger* 134

Characteristics of Greases as Related to Antifriction Bearing Applications . . . . *E. S. Carmichael and R. C. Robinson* 137

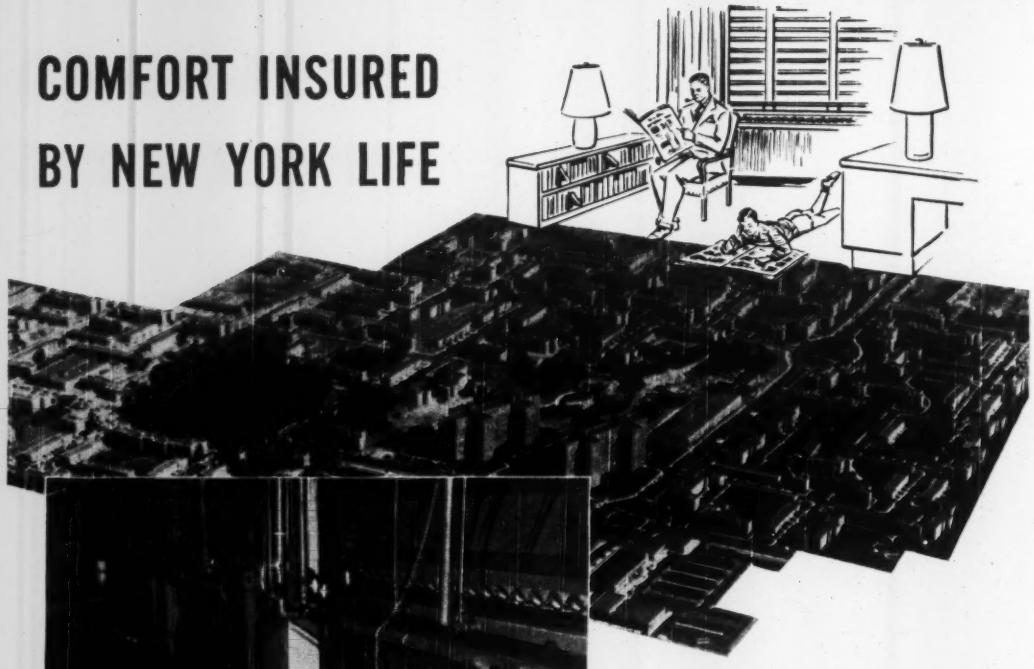
Maintenance of Antifriction Bearings . . . . . *J. M. Bruening* 142

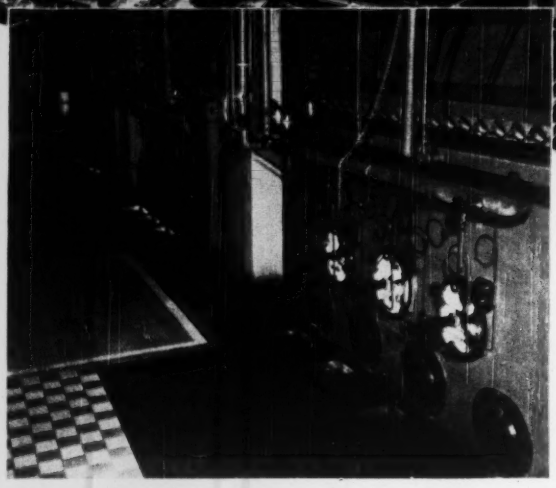
Job Satisfaction and Labor Mobility . . . . . *G. P. Shultz* 145

Departments

Briefing the Record, 147
ASME Technical Digest, 159
The Engineering Profession—News and Notes, 176
ASME News, 186
Keep Informed (Advertisers), 41

COMFORT INSURED BY NEW YORK LIFE





Four B&W Integral-Furnace Boilers, Type FF, installed at Fresh Meadows' central heating plant.

WITH B&W STEAM

Boldly conceived and daringly executed, the new Fresh Meadows 170-acre residential community and shopping center in Long Island, N. Y., is one of the largest and finest of its kind in the United States. Steam for heating the 154 business and residential buildings of this giant development is supplied by four B&W Integral-Furnace Boilers, Type FF, from a centrally located plant. Each of these boilers is capable of operating at a continuous rate of 44,000 lb. of steam per hr. at 200 psi, and at 55,000 lb. for emergencies. Normally oil-fired, the boilers are designed for conversion to stoker firing if desired.

Compactness, ease of simplicity of operation, fuel economy and flexibility, smokeless combustion, low maintenance, and reasonable first cost are some of the advantages of the B&W Integral-Furnace Boiler, Type FF, that make it so attractive for public, private and commercial buildings; institutions; and industrial plants requiring boiler capacities up to 60,000 lb. per hr. It is now satisfying the requirements of over 500 users ranging from airports to zoos.

Send for Bulletin G-64 describing and illustrating the many cost-saving features of this popular boiler. The Babcock & Wilcox Company, 85 Liberty Street, New York 6, N. Y.

B&W

BABCOCK & WILCOX

G-44B

Take a look at something wonderful YOU CAN'T SEE!

When you examine and admire the new models at the winter shows, you'll see many of the devices that make automobiles so dependable today. But not all of them!

You can't see the amazingly accurate New Departure ball bearings beneath the gleaming chrome and lacquer of the new cars. Located where they are, by engineers who perform new "miracles" each year, these *ball* bearings carry the loads, lick wear and friction, and keep moving parts moving, precisely in position, for years and years.

New Departure, world's largest maker of ball bearings, welcomes the increasing acceptance by engineers of the fact that "nothing rolls like a ball."

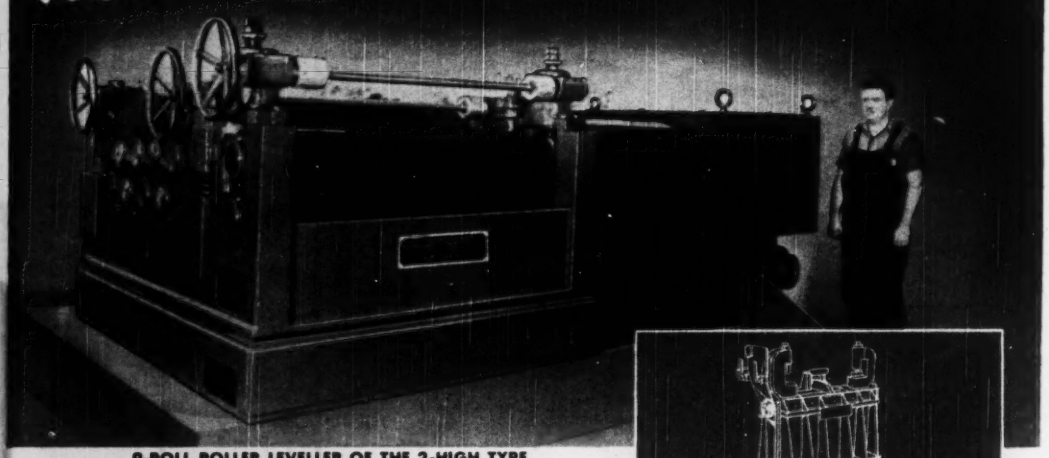
nothing rolls like a ball...

NEW DEPARTURE
BALL BEARINGS

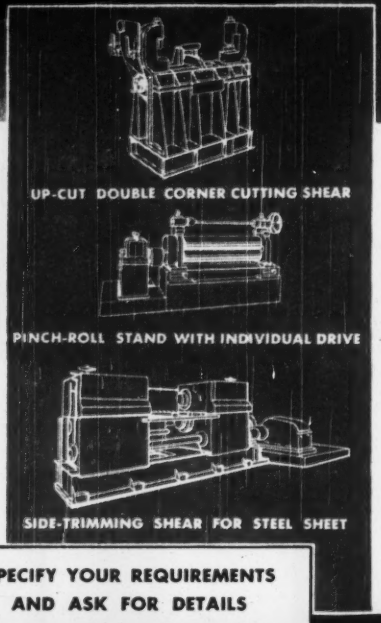
89 NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

MECHANICAL ENGINEERING, February, 1950, Vol. 72, No. 2. Published monthly by The American Society of Mechanical Engineers, at 20th and Northampton Sts., Easton Pa. Editorial and Advertising departments, 29 West 39th St., New York 18, N. Y. Price 75¢ a copy, $7.00 a year; to members and affiliates 50¢ a copy, $4.00 a year. Postage to Canada, 75¢ additional to foreign countries $1.50 additional. Entered as second-class matter December 21, 1920, at the Post Office at Easton, Pa., under the act of March 3, 1879. Member of the Audit Bureau of Circulations.

WE BUILD ROLLING MILL MACHINERY



9-ROLL ROLLER LEVELLER OF THE 2-HIGH TYPE



UP-CUT DOUBLE CORNER CUTTING SHEAR

PINCH-ROLL STAND WITH INDIVIDUAL DRIVE

SIDE-TRIMMING SHEAR FOR STEEL SHEET

for the ferrous and non-ferrous industries

to the individual production requirements of our customers

LEVELLING, TRIMMING AND SHEARING LINE

for Steel Sheet from 15″ to 48″ wide and 0.188″ to 0.4″ thick, up and including J-55

designed and built for the new pipe mill of

KAISER STEEL CORPORATION
KAISER ENGINEERS DIVISION OF KAISER INDUSTRIES, INC.
ENGINEER-CONTRACTOR

SPECIFY YOUR REQUIREMENTS AND ASK FOR DETAILS

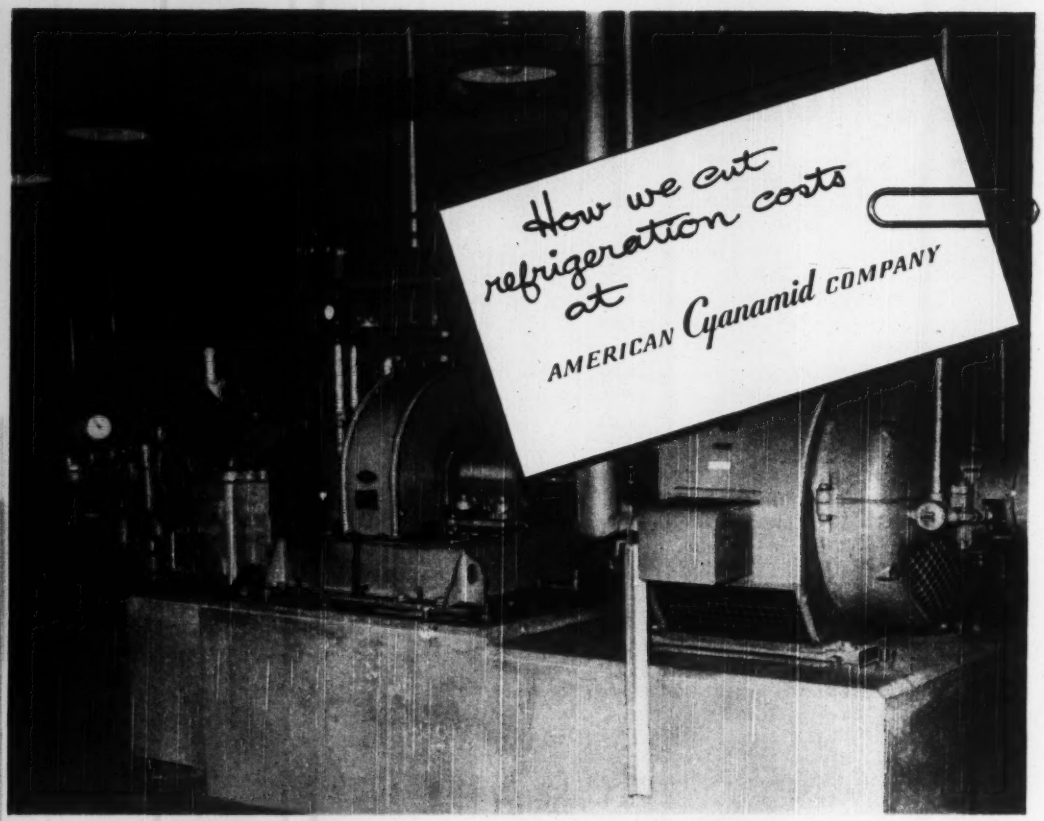
HYDROPRESS · INC.

ENGINEERS CONTRACTORS

HYDRAULIC PRESSES · ROLLING MILLS · PUMPS
ACCUMULATORS · DIE CASTING MACHINES

572-574 LEXINGTON AVENUE NEW YORK 22 · N. Y.

CHICAGO DETROIT SAN FRANCISCO SEATTLE WASHINGTON D. C.



Engineers at the American Cyanamid Company's Linden, N. J., plant know how. Here's the story.

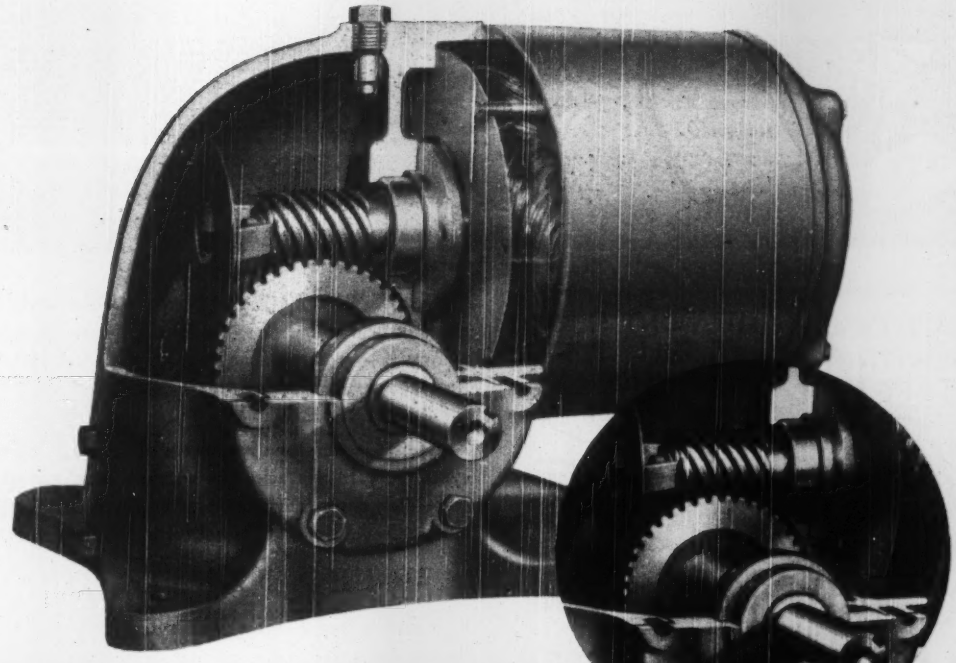
Until recently, reciprocating compressors furnished refrigeration where it was needed. As production increased, however, the engineers were reluctant to add more compressors. Valuable plant space was already being taken up. Maintenance was already scattered.

They decided to bring together all refrigeration apparatus. Consolidation would save valuable space in the plant. It would simplify maintenance and control.

They decided, too, to replace existing equipment with Carrier Centrifugal Refrigerating Machines. The changeover was made gradually without interfering with plant operation. The high operating efficiency of the Centrifugal, its few wearing parts and its simplicity of design added up to substantial economies. Three Carrier Centrifugal Refrigerating Machines now supply over 500 tons of refrigeration at minus 10 degrees F. for the Linden plant of the American Cyanamid Company.

What are your compression or refrigeration requirements? You can get Carrier Centrifugal Refrigeration in capacities up to 1200 tons that will chill directly any liquid . . . condense any vapor . . . reach as low as minus 100 degrees F. Why not call Carrier? Carrier Corporation, Syracuse, N. Y.

Carrier **CENTRIFUGAL COMPRESSORS • REFRIGERATION EQUIPMENT**



G.S. GEARS HELP *Century* MOTORS STAY ON THE JOB!

Century is very particular about the component parts for their products. They feature: "*Century* Motors *stay on the job*—provide satisfactory performance throughout a *long* motor life". It's obvious that only the *finest* Gearing would fill the bill for them . . Gears that give trouble-free performance day in and day out, with economy and smooth operation. Small wonder they specify G.S., for as the world's largest exclusive manufacturers of Small Gears, we've got a lot of tricks up our sleeve to assure the kind of performance required. Don't take chances on the Small Gears you need. Specify G.S.! Recommendations, cost estimates, without obligation. Write now. Or, send for the catalog-bulletin described below.

SEND FOR *free G. S. catalog-bulletin, describing many different types and applications of our Fractional Horsepower Gears.*

FRACTIONAL HORSEPOWER GEARS

GEAR Specialties

Spurs · Spirals · Helicals · Bevels · Internals · Worm Gearing · Racks · Thread Grinding

2635 WEST MEDILL AVENUE · CHICAGO 47, ILLINOIS

MEMBER OF AGMA

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

tape that can take it

You don't exactly buy tape to kick it around,

BUT—

—BUT you'll have to admit that most woven tapes do have to take an awful beating. For years nobody has come up with a better answer than "metallic" woven tapes—with little strands of metal woven into them.

BUT here's something far better—PHOENIX WYTEFACE† *non-metallic* Woven Tapes—a great and radical forward stride in tape development.

As one highway engineer puts it: *"it has at least three times the life of ordinary metallic tapes."*

PHOENIX WYTEFACE has been given the works in grueling field tests—in extremes of climate, in water and mud, over stones and rocks, under truck wheels, through brush and barbed wire—and has come through shining and unscathed.

The secret is, this tape is a weave of amazingly strong synthetic yarns—a scientific wartime development—completely covered by an armor-like plastic coating that is not affected by water, is not brittle, will not flake.

MORE ACCURATE, TOO

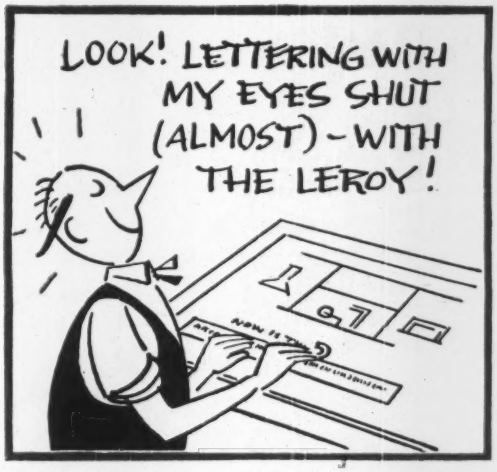
Even after repeated soaking and dryings, this tape won't let you down. It has dimensional stability a lot greater than so-called "metallic" woven tapes.

And it has a HIGHER DIELECTRIC CONSTANT—which is important to power and utility companies and to anyone working near high tension circuits.

The clear black and red markings on the white background almost read themselves out loud, and the surface easily wipes clean as a whistle.

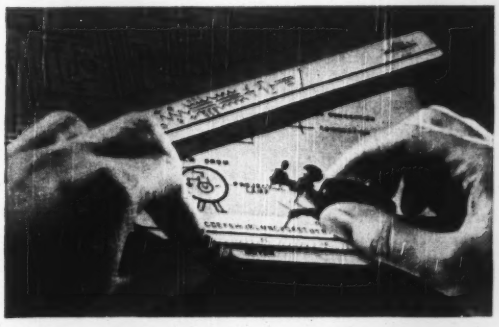
†Trade Mark. U. S. Pat. 2,321,920.

PHOENIX WYTEFACE



beautiful lettering with little effort

Many engineers make perfect drawings and then mess them up with "home made" lettering. A quick easy way to get lettering and symbols which look like type on your drawings is to use a LEROY* "controlled lettering" outfit, a Keuffel & Esser Co. product.



THE MAN WHO HAND LETTERED THIS LINE

DID THIS WITH A LEROY LETTERING SET.

And he had had little experience with LEROY, and it took him no more time.

He didn't even have to rough it in with a pencil or draw guide lines. He chose one of several alphabets (templates) in his kit and followed the character grooves with an easy stroke of the scriber. Then the pen formed perfect letters right where he wanted 'em. A blind man could darned near do it!

LEROY lettering is free from risk of smearing, because the template is well removed from the lettering, and, there's no need for erasing. You have a wide choice of sizes and types of lettering, numerals and symbols.

a tracing paper for the ages

You practically want to think of posterity when you buy tracing paper. Well, there are drawings around today that were made years and years ago on ALBANENE*, and they are today as crisp and sharp as you could ask—which proves that ALBANENE does not turn brittle or lose its transparency with time.

You see, ALBANENE's transparency is due not to oils that leak and "bleed", but to a synthetic transparentizer that K&E developed specially for this purpose—and not for flavoring popcorn.

*Trade Mark ®

Ask your K&E Distributor or Branch for further information on any of these fine products, or for a sample length of PHOENIX WYTEFACE. Or write to Keuffel & Esser Co., Hoboken, N. J.

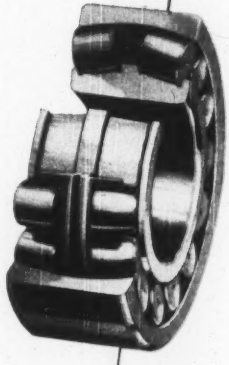
K&E
partners in creating
For 83 years K&E equipment and materials have been partners of the draftsman, engineer, and scientist in shaping the modern world.

NEVER TOO MUCH... NEVER TOO LITTLE BUT ALWAYS JUST RIGHT

because of TOLERANCE CONTROL

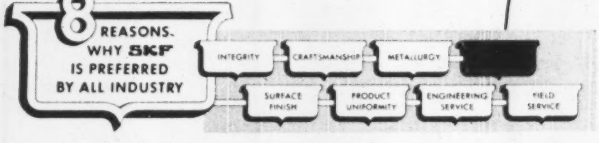
Another reason why industry prefers SKF

Remember leapfrog? How you used to have to skim over just right? Well, it's very much the same thing in specifying bearings. You don't want tolerances too great... and you don't want tolerances closer than the job demands. But you want to be sure that tolerances are *right*... are *always* properly controlled... *always* meet established standards. SKF adheres rigidly to these standards. Ceaseless vigilance in every stage of production assures complete control of tolerance throughout the entire manufacturing cycle. You can always be sure that any SKF Bearing will exactly meet your requirements... and will meet them again and again. Never forget, either, that *tolerance control* is only *one* reason why SKF Bearings will help you build equipment which, through smooth, economical performance, helps develop greater acceptance for your product. **SKF** INDUSTRIES, INC., PHILADELPHIA 32, PA.



SKF

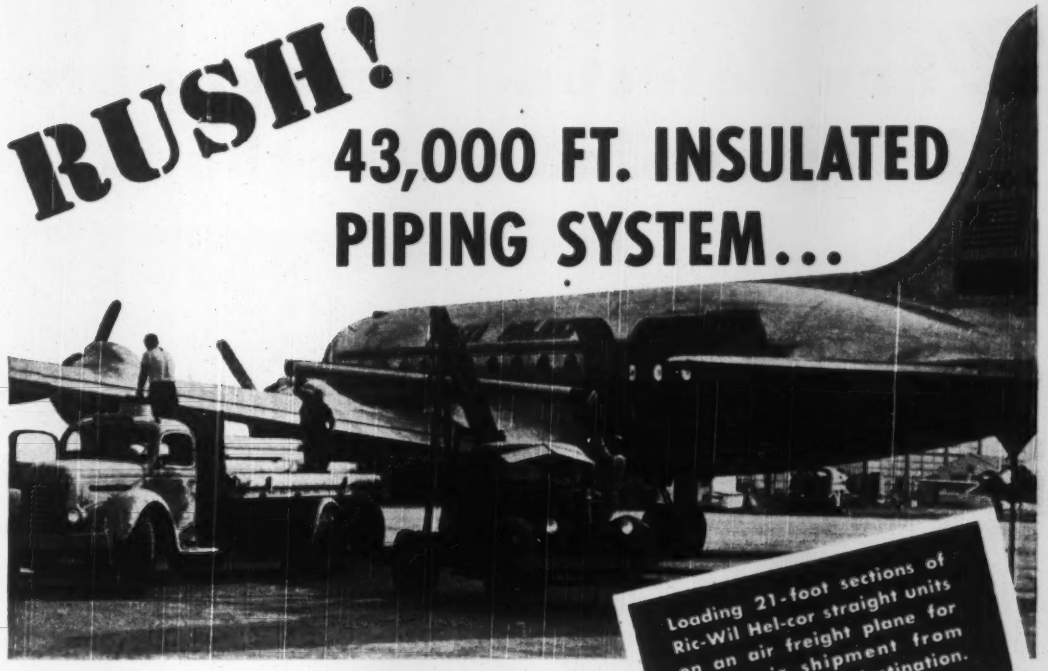
Ball and Roller Bearings



Inventors and Pioneers of the Self-Aligning Ball Bearing and Spherical Roller Bearing

7050

RUSH! 43,000 FT. INSULATED PIPING SYSTEM...



Loading 21-foot sections of Ric-Wil Hel-cor straight units on an air freight plane for direct air shipment from Akron, Ohio to destination.

To meet the rigid construction and installation schedule set up by field engineers on a recent development, Ric-Wil coordinated shipments of material with the schedule by utilizing air freight. Such coordinated planning and production resulted in a great time saving in the project schedule.

This unique air shipment is an example of the careful planning and scheduling of the Ric-Wil engineering and production organization to supply customer requirements.

The proven performance and efficiency of Ric-Wil Insulated Piping Systems is backed by forty years of development, engineering, and production experience.

Prefabricated–
FOR QUICK INSTALLATION

Prefabricated Ric-Wil Elbow Section

Prefabricated Ric-Wil Tee Section

For full technical information on Ric-Wil Systems call or write the Ric-Wil office nearest you or Dept. 14-G in Cleveland, Ohio.

RIC-WIL
INSULATED PIPING SYSTEMS
OVERHEAD — THE RIC-WIL COMPANY · CLEVELAND, O. — UNDERGROUND

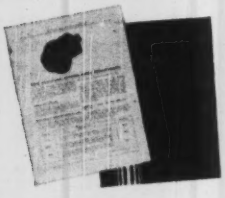
FOR FORTY YEARS THE GREATEST NAME IN INSULATED PIPING SYSTEMS

When detecting temperature by radiation method . . .

Quick-sighting optical system **lets user select desired target easily, and then check the sharply-defined area which the Rayotube sees. Increased sharpness is also of benefit when radiation comes from end of a closed tube.**

Hermetically sealed construction **at lens, window, and leadwires keeps out dust and gases. New design guards inherent accuracy and stability, even with high or rapidly changing Rayotube housing temperatures.**

Which do you want?



If you already know about Rayotubes, we'll send you brief material to bring you up-to-date on the new model. If you want the full story on all Rayotubes, ask for Cat. N-33B. Please specify. Write Leeds & Northrup Company, 4963 Stenton Ave., Phila. 44, Pa.

Built to work with all Micromax and Speedomax Rayotube instruments, this new Rayotube is an important advance in radiation pyrometry. Present users of Rayotubes, as well as future ones, will find this completely new, advanced design detector unusually easy to apply, especially to such equipment as slab furnaces, soaking pits, open-hearths, ceramic kilns . . . wherever operating conditions are severe.

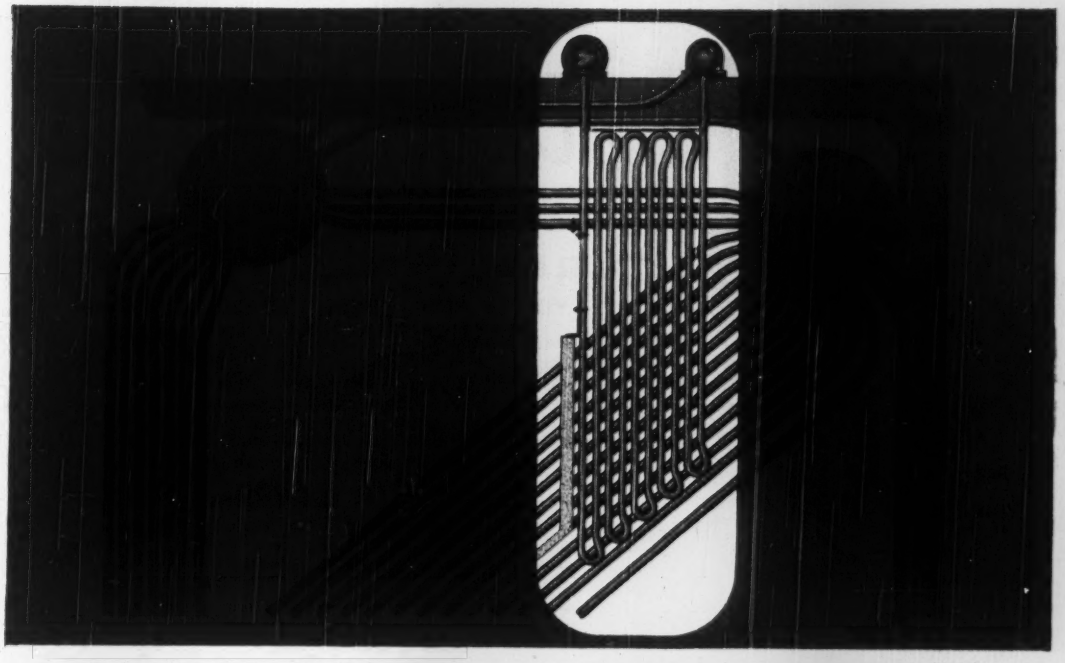
Purposely designed for easy, low cost replacement, the new Rayotube fits all existing Rayotube mountings. This unit requires no protection against high ambient temperature unless its housing temperature exceeds the very high figure of 350 F. Below that point, any previously installed water- or air-cooling can simply be turned off or disconnected.

Temperature control engineers will welcome these and many other new concepts of design built into this highly versatile temperature detector.

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

Jrl. Ad NS3(1)



THE ERIE CITY SUPERHEATER

The illustration above shows one of the many types of superheaters designed and produced by Erie City to meet the exacting requirements of the modern steam generator. This particular example is the vertical pendant type.

The horizontal steam take-off serves also as the superheater inlet header, thus making the superheater an integral part of the boiler and simplifying installation and maintenance.

This familiar method of taking steam from an Erie City boiler in a transverse series of tubes, instead of a single nozzle, produces steam with high initial dryness and allows the superheater to perform with maximum efficiency and safety.

Our Steam Generator Bulletin (SB-30) illustrates and describes many types of superheaters engineered and manufactured within our own plant. It is available on request.

COMPLETE STEAM POWER PLANT EQUIPMENT

ERIE CITY

Complete Steam Generators • Type C 3-Drum Boilers • Type VL 2-Drum Boilers • The "Economic" Boiler with or without Water Walls • Welded H. R. T. Boilers • Welded Steel Heating Boilers • Coal Pulverizers • Underfeed and Spreader Stokers • Welded Pressure Vessels for the Process Industries.

ERIE CITY IRON WORKS • ERIE, PA. • *Since 1840*

...Digging for facts

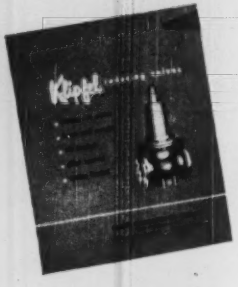
ON AUTOMATIC REGULATING VALVES?

YOU'LL FIND THESE KLIPFEL BULLETINS PRACTICAL, FACTUAL AND USEFUL!

Klipfel engineers have put a lot of experience and research into these bulletins to make them useful to you . . . the man who uses or specifies automatic regulating valves. Each bulletin covers such points as: the advantages and limitations of different valve constructions; selecting the proper type valve for given operating conditions; determining the most effective and economic size valve for the job.

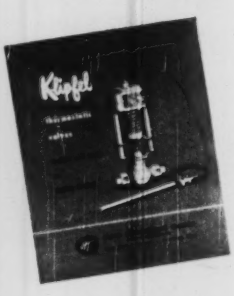
In short, Klipfel engineers have prepared these bulletins to assist you in selecting the type and size valve best suited to your needs.

Write Dept. CM2 for any bulletins you wish. We'll gladly send them to you.



KLIPFEL REDUCING VALVES
for steam, air and water . . . in lever and weight, air loaded, pilot control and spring loaded types; descriptions, illustrations and complete selection data in Bulletin 148.

KLIPFEL FLOAT VALVES
Single and double seated types with direct action or pilot control for remote location. Types shown include quick-acting valves; all are available in angle and globe patterns. Bulletin 349.



KLIPFEL THERMOSTATIC VALVES
vapor pressure operated valves with spring or weight and lever loading. Valves are ball type, balanced cup and disc or balanced inner valves. Min. temp. 80°. Max. temp. 250°. Range limit of any instrument 40°.

KLIPFEL BACK PRESSURE AND RELIEF VALVES
for control of air, steam and water pressures at the valve inlet in various types for practically any service. Bulletin 648 gives complete details including dimensions and capacities.

Klipfel VALVES INCORPORATED

DIVISION OF HAMILTON - THOMAS CORPORATION, HAMILTON, OHIO

FULL LINE . .
FULL VALUE . . .
FULL SERVICE . . . .

We have repeatedly urged users of welding fittings to accept no less than the *full line.* When we say "full line" we don't just mean its *completeness* . . . though it *is* the world's most complete line of forged steel fittings and flanges . . . and it *does* contain the widest range of types, sizes, weights and materials.

When we say "full line" we mean full value—extra value—more and better features than can be found in any other fitting. The technical brains and forging skills which conceived these extra values continue to be available to you through the Taylor Forge organization, and through the Taylor Forge distributor who is your industrial neighbor.

Since Taylor Forge welding fittings "have everything," why compromise on less than the best?

TAYLOR FORGE

TAYLOR FORGE & PIPE WORKS General Offices & Works: Chicago 90, Ill. (P.O. Box 485) Eastern Plant: Carnegie, Pa. Western Plant: Fontana, Calif. • District Offices—New York: 50 Church Street • Philadelphia: Broad Street Station Bldg. • Pittsburgh: First National Bank Bldg. • Chicago District Sales: 208 S. LaSalle Street • Houston: City National Bank Bldg. • Los Angeles: Subway Terminal Bldg.

Please send a copy of your new catalog 484 covering welding fittings and forged steel flanges.

Name .....

Position .....

Company .....

Street address .....

City ..... Zone ..... State .....

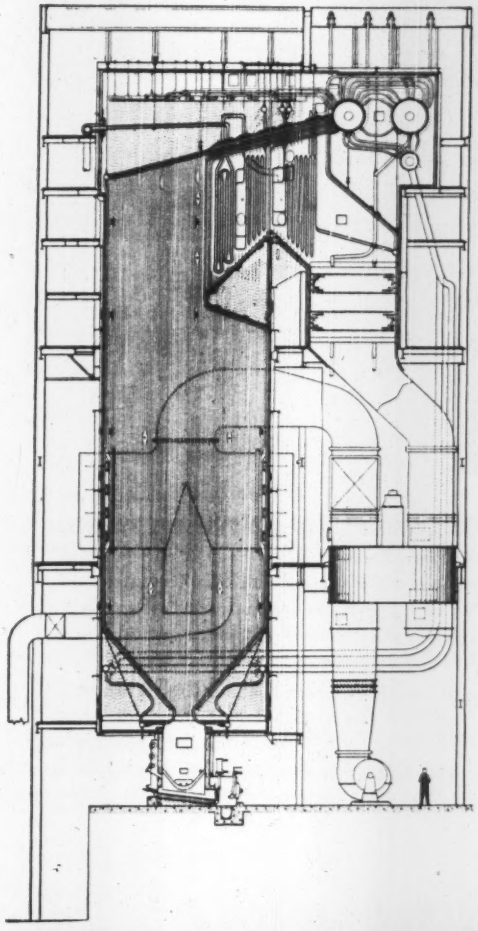
505-4250 Mail to Taylor Forge & Pipe Works, P.O. Box 485, Chicago 90, Ill.

WE
WELCOME
SMALL
ORDERS
Quick Deliveries
Wallace Barnes Springs
Bristol Connecticut

Recent C-E Steam Generating Units for Utilities

HAWTHORN STEAM ELECTRIC STATION

KANSAS CITY POWER & LIGHT COMPANY



THE C-E Unit illustrated here is one of two duplicate units now in process of fabrication for the new Hawthorn Steam Electric Station of the Kansas City Power & Light Company.

Each unit is designed to produce, at maximum continuous rating, 625,000 lb of steam per hr at 1335 psi and 955 F.

These units are of the radiant type with 3-stage superheaters followed by finned tube economizer surface and regenerative type air heaters.

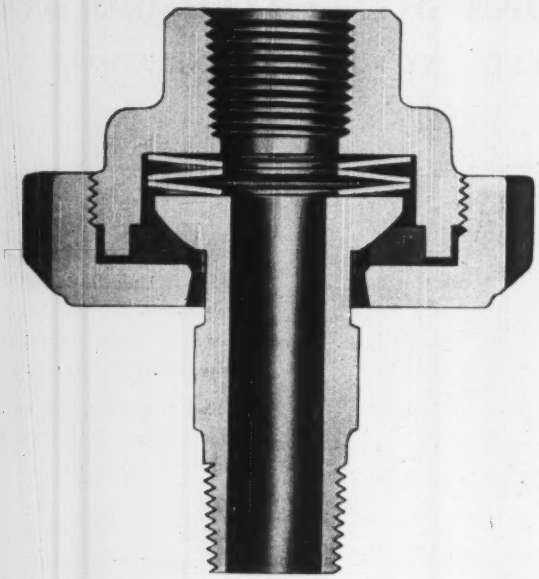
The furnaces are completely water cooled using part plain tube and part finned tube surface. They are of the basket-bottom type discharging to sluicing hoppers.

Pulverized coal firing is employed using bowl mills and vertically-adjustable, tangential burners. Provision is also made for the use of natural gas as an alternate fuel.

B-354

C-E

Improved Barco Rotary Swivel Joints
FOR MINIMUM FRICTION



FRICTION-FREE PERFORMANCE WITH LOWER TURNING TORQUE. This compact, lightweight, low cost joint is especially efficient at high and low temperatures and pressures. It handles alternating steam and cold water without leakage. It is much more compact for the same capacity and has performed successfully on continuous rotation applications up to 30 RPM. This new, low torque joint will greatly reduce power costs and worker fatigue. It is practically maintenance free.

WIDE TEMPERATURE AND PRESSURE RANGES. The new Barco Rotary Swivel Joints withstand these extreme ranges with complete safety, no chance of bursting. Angular motion compensates for misalignment and there is no restricted internal diameter as in flexible hose.

• • •

Install these remarkable joints now. Our engineers will gladly discuss your problems. Sizes ⅜", ½", ¾", 1". When ordering, give complete information about pressures, temperatures, fluids or gases, and any other special conditions.

BARCO ***FLEXIBLE JOINTS***

Not just a swivel joint ...but a combination of a swivel and ball joint with rotary motion and responsive movement through every angle.

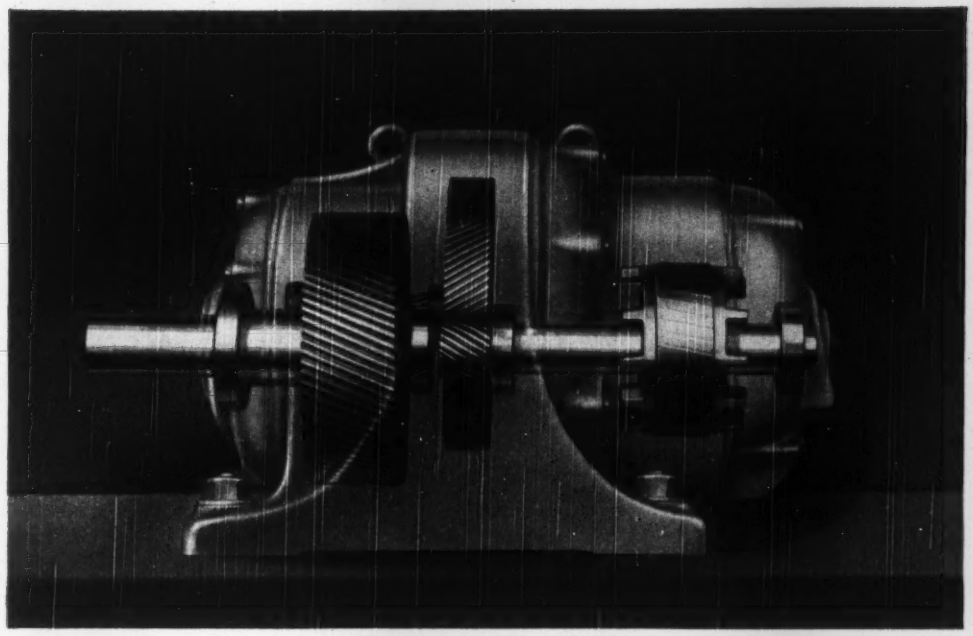
FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY

"MOVE IN EVERY DIRECTION"

BARCO MANUFACTURING COMPANY,

1807 C. Winnemac Avenue, Chicago 40, Illinois • ***In Canada:*** **THE HOLDEN CO., LTD., MONTREAL, CANADA**

U. S. SYNCROGEAR MOTOR



Diaphanous view of U. S. Syncrogear Motor.

THE GEARED MOTOR WITH PYRAMIDAL STABILITY

DEPENDABILITY

Rugged pyramidal base withstands external stresses. Hardened gears are designed for high safety factor. Lubrication is positive.

ECONOMICAL OPERATION

Helical gears and full anti-friction bearings contribute to high efficiency. No rubbing seals to wear and cause leakage.

LONG LIFE

Gears are hardened to 45/50 Rockwell C. All motor windings are asbestos protected. Normalized castings maintain accuracy.

COMPACTNESS

Integral design eliminates couplings. High speed motor for efficient power conversion. Solid shank pinion permits greater ratio.

QUIET OPERATION

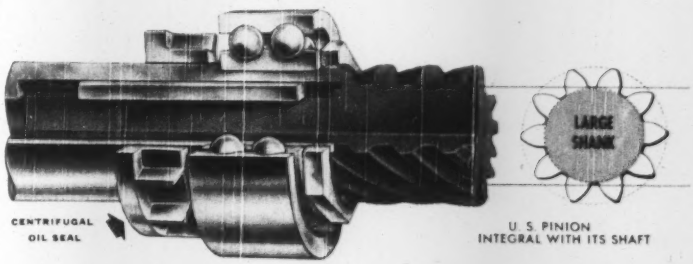
Simple helical gear trains, precision finished, are permanently held in alignment. Low pitch line velocities are used.

MANY TYPES AND SIZES

Single, double, and triple reductions are available in sizes of ¼ to 30 h.p. and standard AGMA speeds of 10 to 10,000 RPM.

U. S. SOLID SHANK PINION

The vital high speed pinion in Syncrogears is integral with its shaft; therefore cannot vibrate or work loose. Its solid, oversize diameter reduces deflection to almost one-half that of the ordinary type. The motor shaft is bored hollow to receive the pinion. Maximum strength is obtained by this advanced design.



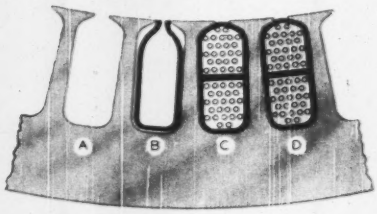
See next page

Type GR—Single Reduction Syncrogear

U.S. MOTORS,

ASBESTOS PROTECTION

PREVENTS CARBONIZATION



Life of a motor is proportional to life of the insulation protecting the windings. All U. S. Motors are asbestos-protected. Asbestos cannot carbonize. The windings are insulated with asbestos and electrically impregnated with Asbestosite. Each wire is insulated with asbestos. Above drawing shows the progressive steps in insulation. (A) empty stator slot; (B) formed cell of asbestos heatproof wall; (C) wires inserted within asbestos enclosures; (D) Asbestosite forced around each wire.

NORMALIZED CASTINGS

HEAT-SEASONED FOR ACCURACY

All fine precision parts such as those used in giant telescopes, artillery guns, gears, angle blocks and surface plates are invariably normalized. So likewise are U. S. Motor parts.

Heat-seasoning by the U. S. normalizing process *stabilizes the molecular structure* of castings. By removing internal stresses before a cast iron part is machined, endurance and accuracy are forever assured. Every part of the motor maintains its original precision throughout its life. U. S. normalized castings are more costly to produce than ordinary castings, but the sustained efficiency and prolonged motor life thus induced, more than justify the added expense. Life-long durability is *assured.*

For ever-dependable geared power, install the U. S. Syncrogear. Its accuracy of parts and perfection of hardened gears earn greatest operating economy.

U. S. castings undergoing normalization. Permanent alignment of gears and bearings is thereby assured. This is an added plus value in every U. S. Motor.

Write for new illustrated, descriptive Bulletin

U.S. ELECTRICAL MOTORS Inc.

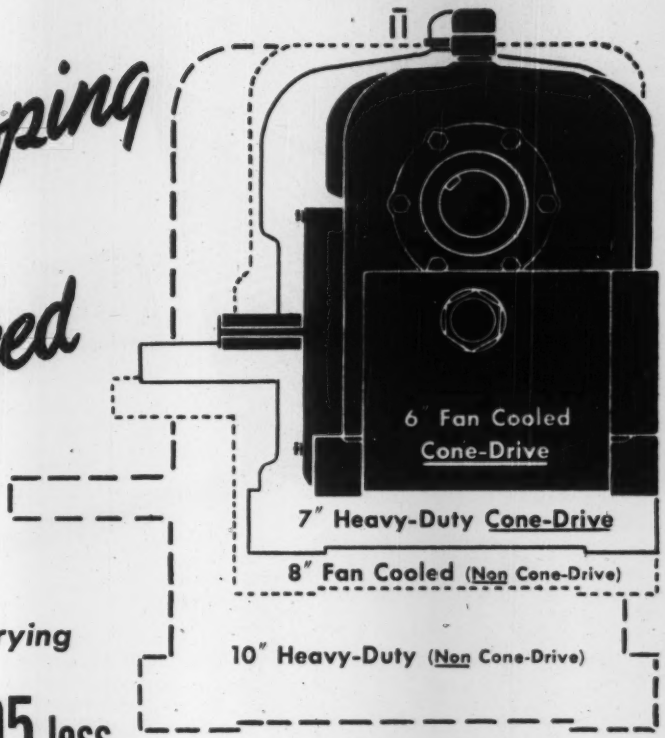
ATLANTIC PLANT: Milford, Conn. • PACIFIC PLANT: Los Angeles 54, Calif.

District Offices: Boston 16, New York 6, Philadelphia 2, Pittsburgh 22, Chicago 8, San Francisco 7, Seattle 4

Example { 5½ hp at 870 rpm; 60 to 1; Class 1 service

To handle this load would call for one of these

*Here's what Cone-Drive double-enveloping gears save you in speed reducers**



For the same load carrying capacity:

8" Fan Cooled Non-Cone-Drive costs . . $95 less

7" Heavy-Duty CONE-DRIVE costs . . $113 less

6" Fan Cooled CONE-DRIVE costs . . $257 less

*—Based on approximate resale prices, Jan. 1st, 1950

. . . and similar savings on gear sets

Cone-Drive Gears and Reducers handle more load—cost less, due to Cone Drive's double-enveloping gearing.

In Cone-Drive you can also get the triple benefits of

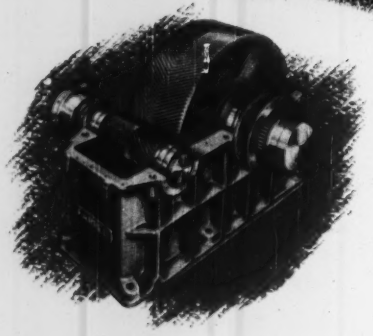
Standard gears
Standard housings
Standard fan-cooled attachments

CONE-DRIVE GEARS

Division, Michigan Tool Company

DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS

7171 E. McNichols Road • Detroit 12, Michigan



On page 5 of Farrel's latest bulletin on speed reducers, you will find a description of the *Gear with a Backbone* —the type of gear used in Farrel gear units.

The *backbone,* formed where the helices meet, makes the teeth continuous across the gear, providing extra strength and greater load-carrying and shock capacity —especially important in heavy-duty speed reducers. Precision generation by the famous Farrel-Sykes method assures accuracy of tooth spacing, tooth contour and helix angle, which pay off in smooth, quiet, uniform operation.

In addition to describing the gears, this bulletin also contains specifications, horsepower rating tables, overhung load capacities, dimensions and weights of single, double and triple reduction units.

If you buy or specify speed reducers, you should have a copy of this informative manual. Fill out the coupon and mail it today.

FB-562

FARREL-BIRMINGHAM COMPANY, INC.
344 VULCAN STREET, BUFFALO 7, N. Y.

Please send me, without cost or obligation, a copy of Bulletin 449, "Farrel Speed Reducers."

Name ..... Title .....

Company .....

Address .....

City ..... State .....

FARREL-BIRMINGHAM CO., INC., 344 Vulcan St., Buffalo 7, N.Y.

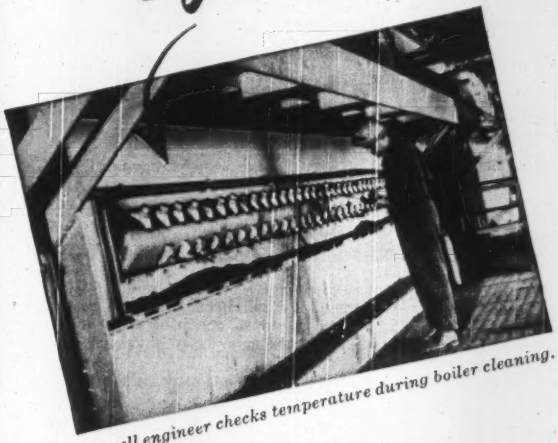
Plants: Ansonia and Derby, Conn., Buffalo, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Boston, Pittsburgh, Akron, Cleveland, Detroit, Chicago, Los Angeles, Tulsa, Houston

Farrel-Birmingham®

DOWELL

SERVICE SPECIALISTS IN MAINTENANCE CLEANING PROBLEMS

Big Boiler Cleaned in ONE DAY by Dowell Service!



Dowell engineer checks temperature during boiler cleaning.

Quick, Effective Maintenance Service Cuts Total Down Time in Half

A TYPICAL EXAMPLE of the economies afforded by Dowell Service is reported in the case of a midwestern refinery using five 300,000 lb. per hour boilers to generate electrical power. Before Dowell Service was used in the plant, boilers were usually down two weeks whenever repairs became necessary—during which time electricity was purchased from an outside source. Using Dowell Service to do the internal surface cleaning, the boiler is back in use in one week instead of the usual two! And the Dowell part of the operation takes just one day!

Dowell Service, using the experience of thousands of successful jobs, offers you the solution to maintenance problems of this type. It is backed by strong, continuous research programs, both in Dowell's own laboratories and in those of The Dow Chemical Company. This research provides the means for an improving service with an increasing degree of effectiveness and safety.

When you call on Dowell Service for your maintenance cleaning, experienced Dowell engineers do the job for you. They bring the special equipment—truck-mounted tanks, mixers, heaters, and proportioners—necessary for controlled cleaning. No dismantling or scaffolding is required. Liquid solvents are pumped into the equipment through regular connections. Down time is held to a minimum.

For quick, practical, economical cleaning of boilers, heat exchange equipment, water lines and water wells, call the nearest Dowell office. Free cost estimates gladly given.

DOWELL INCORPORATED · TULSA 3, OKLAHOMA

SUBSIDIARY OF THE DOW CHEMICAL COMPANY

CALL

New York 20, Boston 16, Philadelphia 2, Baltimore 18, Wilmington 99, Richmond 19, Atlanta, Buffalo 2, Cleveland 13, Pittsburgh 19, Detroit 2, Chicago 2, St. Louis 8, Indianapolis, Louisville, Kansas City 8, Wichita 2, Oklahoma City 2, Houston 2, New Orleans 12, Ft. Worth 2, Shreveport 69, Anniston, Alabama, Mt. Pleasant, Mich., Hamilton, Ohio, Charleston 27, W. Va., Salem, Illinois, Borger, Texas, Midland, Texas, Wichita Falls, Texas, Lafayette, La.

Long Beach, Oakland, Casper: Dowell Associate—International Cementers, Inc.

DOWELL

American Blower—a time-honored name in air handling

In the San Francisco area, for air handling data call American Blower—Sutter 1024. In other areas consult your phone book. NOTE: To better serve our Western customers, American Blower has built another new plant—conveniently located in San Leandro, California.

If you look before you buy, we're certain you'll buy American Blower Air Handling Equipment. There's a vast difference in quality, design, quietness, operating costs and efficiency. Users' records prove the superiority of American Blower products.

Air is free . . . use it profitably!

NO MATTER what business you're in, or where you're located, bear these two things in mind:

1. There are American Blower Air Handling Products which are ideally suited to help you put air to work profitably.
2. There is an American Blower Branch Office strategically located to assist you.

And no matter what type of American Blower equipment you buy, you get these plus advantages:

Equipment built by a reputable manufacturer with a background of 69 years of experience—equipment which is tested in accordance with the Standard Test Code and carries Certified Ratings—equipment which is the result of the broadest and most thorough methods of engineering and research known.

To buyers of American Blower equipment, whether it be power plant equipment—mechanical draft fans, fly ash precipitators, Gyrol Fluid Drives for fan control and boiler feed pumps, or air handling equipment for any need—these plus values insure longer, more dependable service and lower operating costs.

Our nearest branch office will give you full data.

AMERICAN BLOWER CORPORATION, DETROIT 32, MICHIGAN
CANADIAN SIROCCO COMPANY, LTD., WINDSOR, ONTARIO
Division of AMERICAN RADIATOR & Standard Sanitary CORPORATION

YOUR BEST BUY
AMERICAN BLOWER
AIR HANDLING EQUIPMENT

Serving home and industry
AMERICAN-STANDARD • AMERICAN BLOWER • CHURCH SEATS • DETROIT LUBRICATOR • KEWANEE BOILERS • ROSS HEATER • TONAWANDA IRON

2 Ways TO GREATER ECONOMIES

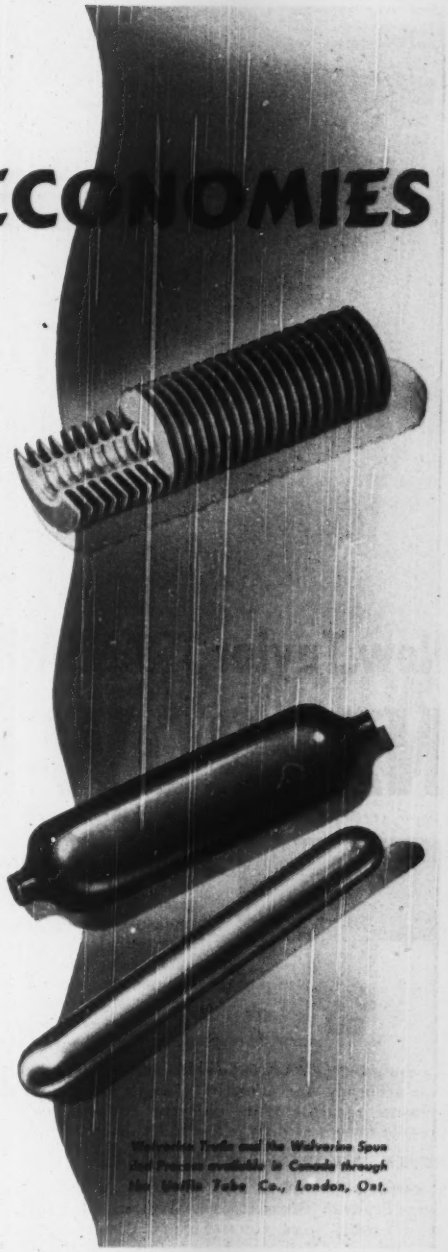
use Wolverine *Trufin for heat transfer

Worthwhile savings are effected in most installations. Unit costs are decreased because less tubing is required for each installation; consequently, the use of much other material is eliminated. Labor, too, is reduced. Note in the illustration how the fins are formed from the tube itself to give you a finned tube that will withstand vibration and extreme temperature changes.

use Wolverine Spun End Process for tubular parts

Plain tubing is often employed in the fabrication of tubular parts because it has been found so much more economical than other methods of forming. This is particularly true in cases where the ends are formed in special shapes—with or without openings. For this fabrication investigate the Wolverine Spun End Process.

*REG. U. S. PAT. OFFICE



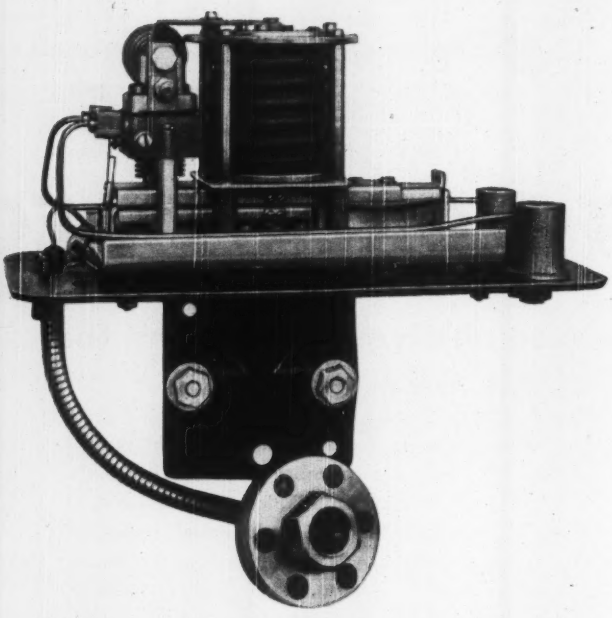
Wolverine Trufin and the Wolverine Spun End Process available in Canada through the Union Tube Co., London, Ont.

WOLVERINE TUBE DIVISION
Calumet & Hecla Consolidated Copper Company
1437 **CENTRAL AVE.** **DETROIT 9, MICHIGAN**
MANUFACTURERS OF SEAMLESS, NON-FERROUS TUBING

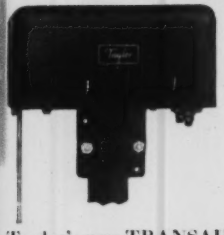
Plants at Detroit and Decatur, Ala.

PLANTS IN DETROIT AND DECATUR, ALA.
Sales Offices in Principal Cities

Now you can measure and transmit smallest pressure changes with TAYLOR ACCURACY!



New Taylor TRANSAIRE* Pressure Transmitter with NARROW RANGE SPANS



FIRST TIME in history! A simple force-balance pressure instrument that measures and transmits the smallest pressure changes up to 1000 ft. with an accuracy of ½% of the range span (*conventional devices are only accurate up to ½% of upper range limit.*)

Taylor's new TRANSAIRE Pressure Transmitter gives you accuracy and sensitivity never before possible in pressure measurement—plus the convenience of suppressed ranges at high pressure levels.

SEVEN IMPORTANT ADVANTAGES:

1. RANGE SPANS OF 20 AND 40 PSI available throughout range limits of 35 to 415 psia. With accuracy established at ½% range span, you can expect precise measurement to .1 psi with 20 psi spans, and .2 psi with 40 psi spans—and consequently proportionately closer control.

2. VOLUMETRIC TYPE PRESSURE SYSTEM is extremely accurate. Being a completely closed system there is practically no hazard of clogging. Type 316 stainless steel diaphragm and connection give maximum corrosion resistance.

3. PERFECT FOR MANY JOBS, especially on thin fractionating columns in chemical and petroleum industries, etc.

4. STANDARDIZED 3 TO 15 PSI OUTPUT Air Pressure means you don't have to individually calibrate receivers or receiver-controllers. Instrument transmits output pressure in proportion to measured pressure with accuracy of ±0.06 psi.

5. OPERATING RANGE VARIED by simple screwdriver adjustment.

6. INTERCHANGEABLE MANIFOLD ASSEMBLIES make 20 and 40 psi range spans optional.

7. INSTRUMENT QUICKLY TRANSFERRED from one job to another having different range by simply inter-changing spring sub-assemblies.

This Taylor TRANSAIRE Pressure Transmitter is another step in Taylor's program to produce industrial instrumentation unsurpassed in *accuracy*, *simplicity*, and *durability*. We're doing this, of course, to help you keep costs down and quality up. Ask your Taylor Field Engineer! Or write for **BULLETIN 98099.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

Instruments for indicating, recording and controlling temperature, pressure, humidity, flow and liquid level.

* Trade-Mark

TAYLOR INSTRUMENTS MEAN ACCURACY FIRST

NEW all-electric ADJUSTABLE-SPEED GEAR-MOTOR

$559*

TRI/CLAD ACA GEAR-MOTOR

REG. U.S. PAT. OFF.

LOW COST ★ LOW OUTPUT ADJUSTABLE SPEED ★ LOW MAINTENANCE AND INSTALLATION COSTS

Buy General Electric and get

Stepless, low, adjustable output speed
Extra load-carrying capacity in less space
Easier mounting in less space
Industry-proved Tri-Clad construction
Double-barrelled efficiency because of low motor and gear losses
Reduced maintenance costs

They are available in standard ratings from 3-15 horsepower 35/12 to 602/201 rpm.

A right answer for your low-output stepless adjustable-speed-drive applications, our ACA gear motor will do an outstanding job for you driving

Conveyors	**Agitators**
Reciprocating pumps	**Mixers**

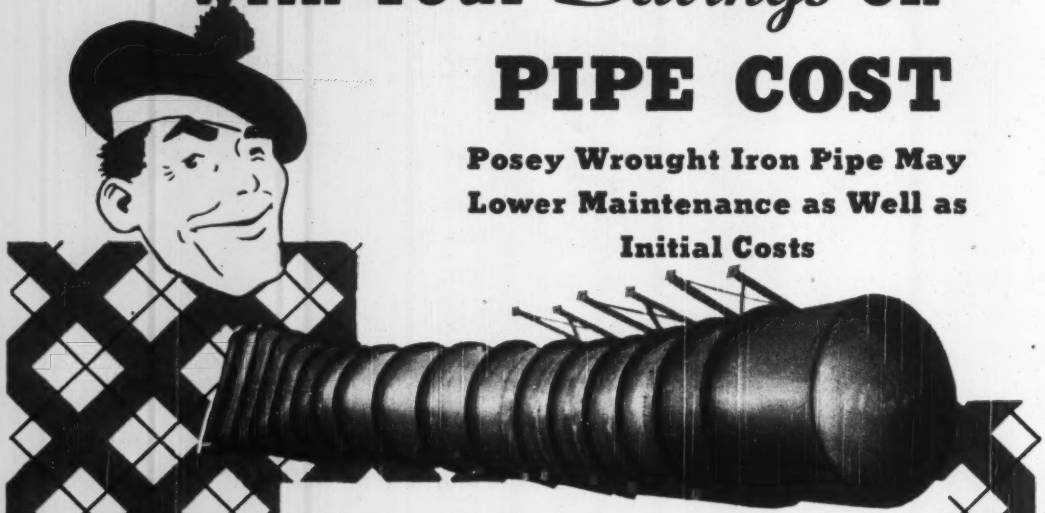
For the majority of your low-speed drives, standard ACA gear-motors fill the bill. Other ratings in large horsepowers, or lower speeds or wider speed ranges are available on proposition request.

NOW IS THE TIME TO FILL YOUR NEEDS ON ALL GEAR-motor requirements. Call your nearest General Electric Sales Office or your local distributor. ***Apparatus Dept., General Electric Company, Schenectady 5, N. Y.***

* Manufacturers suggested list price.

Your *Savings* Only BEGIN with Your *Savings* on PIPE COST

Posey Wrought Iron Pipe May Lower Maintenance as Well as Initial Costs



Whether your requirements are "run-of-the-mill" . . . or whether they involve unusual problems in pipe design and installation . . . a Posey estimate may be your first step toward a worthwhile economy. You can *save* not only at the time you purchase . . . but over and over again throughout the long, *low-maintenance* life of Posey Wrought Iron Pipe.

At the Posey Iron Works—established since 1910—experience has eliminated needless, cost-boosting fabrication steps . . . while improving flow capacity and holding pipe diameters and trench depths to a minimum. Maintenance costs are also reduced because durable Posey construction resists time and pressures . . . because tight Posey joints seal out roots.

Write Posey and state your service conditions. Our study of them may permit us to point out definite economies. No obligation, of course.

Established since 1910

NEW YORK: Graybar Building

POSEY IRON WORKS, INC.

formerly LANCASTER IRON WORKS, INC.

LANCASTER, PENNA., U.S.A.

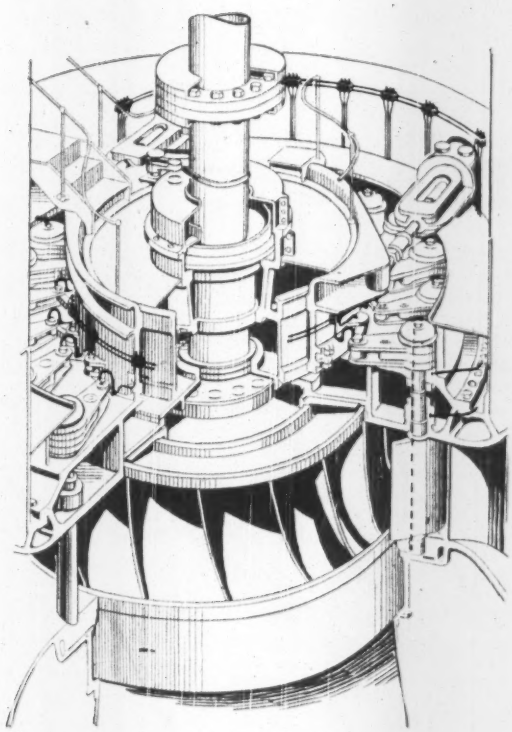
DIVISIONS Steel Plate · Asphalt · Steel Form · Brick Machinery

Renewed only 4 bearings in 12 years with Farval

FARVAL solves the problem of lubricating turbines in hydraulic turbo-generator plants, according to reports from station managers.

On one Farval-lubricated turbine, only four bearings were renewed in 12 years. Prior to the installation of centralized lubrication it had been necessary at this plant to replace 6 to 8 bushings every six months, each time the turbine was dewatered.

Another plant engineer says, "After 14 years we are well satisfied with Farval. When our turbines were overhauled we found very little wear on moving parts and linkages." Still another man writes, "We would never go back to the individual grease fittings of years ago. You can bet that all future turbines will be equipped with Farval."



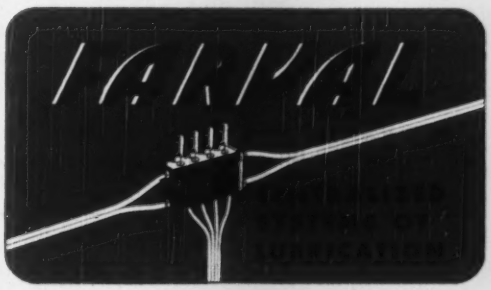
Shutting down a turbo-generator set to replace a worn or damaged bearing is expensive in labor and parts, costly in time and crippling to electric power production. Here as with so many operations throughout industry, Farval lubrication keeps equipment running efficiently, eliminating downtime and safeguarding production, not to mention the saving of labor, lubricant and new bearing costs.

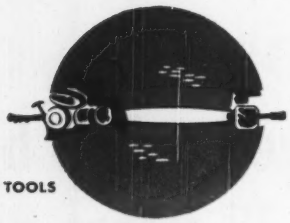
Farval has proven itself in over 20 years of service. It is the original Dualine system of centralized lubrication that others imitate. The Farval valve has only 2 moving parts—is simple, sure and foolproof, without springs, ball-checks or pinhole ports to cause trouble. Through its wide valve ports and full hydraulic operation, Farval unfailingly delivers grease or oil to each bearing—as much as you want, exactly measured—as often as desired. Indicators at every bearing show that each valve has functioned. For a full description, write for Bulletin No. 25.

The Farval Corporation, 3264 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

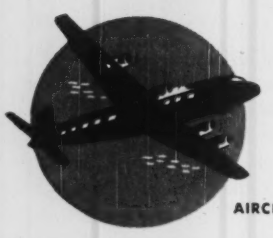
FARVAL — *Studies in Centralized Lubrication* No. 110





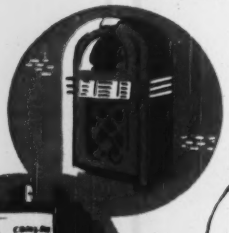
HAND POWER TOOLS

helping hand

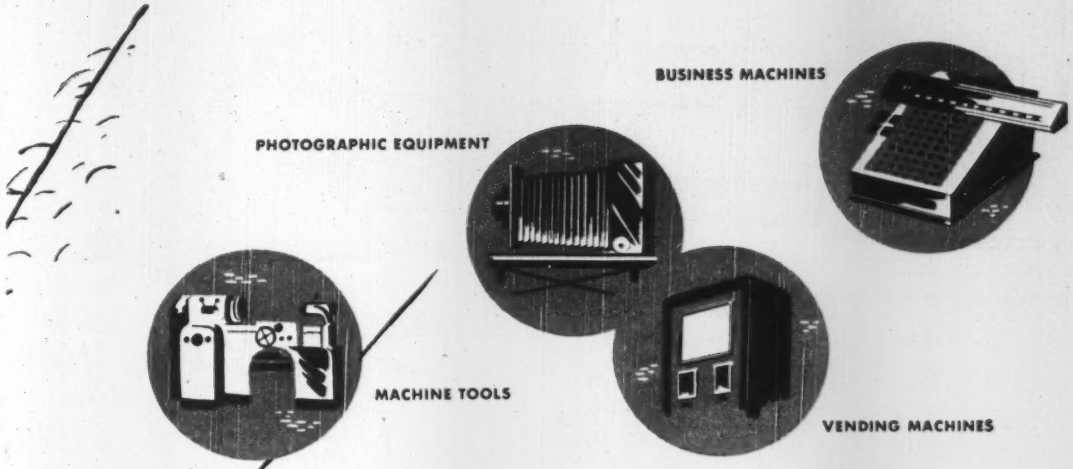


AIRCRAFT

JUKE BOXES



DISPLAYS

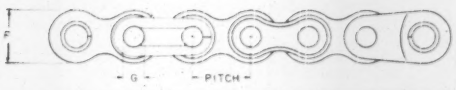


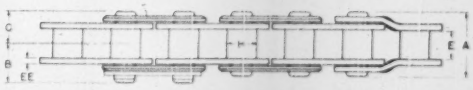
for machine designers!

Machine designers! Here's the newest addition to the complete Baldwin-Rex line of precision-made roller chains. It is the answer to that problem of transmitting positive power where space is limited, where centers are extremely short, where savings in weight and a combination of high strength and accurate timing are required . . . Baldwin-Rex No. 25 Roller Chain. This ¼-inch pitch chain is as finely made . . . as long lasting . . . as versatile and positive as the larger size roller chains. And despite its small size, it has an ultimate strength of 875 pounds . . . an important advantage where reduced maintenance and service are needed.

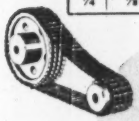
Hand power tools, juke boxes, animated displays, machine tools, photographic equipment, electronic equipment, television equipment, business machines, model equipment and many other types of high precision, small size equipment can be more efficiently designed with this new helping hand to the designer. In many larger types of equipment, too, this handy little chain can motivate intricate timing functions that must be designed into small space.

For all the facts, write Baldwin-Duckworth Division of Chain Belt Company, 363 Plainfield Street, Springfield 2, Massachusetts.





Principal Dimens.			LIST PRICES				DIMENSIONS — INCHES							
Pitch	Roller Width	Roller Diam.	Riveted Chain Per foot	Connecting Link Each	Assembled Roller Link Each	Offset Link Each	Overall Riveted A	From Pin End to C.L. B	From Pin Head to C.L. C	Side Plate Thickness EE	Side Plate Height F	Pin Diam. G	Average Ultimate Strength Lbs.	Average Weight per Foot Lbs.
¼	⅛	0.130	$1.10	$.14	$.10	$.40	0.31	0.19	0.15	0.030	0.23	.0905	875	.085



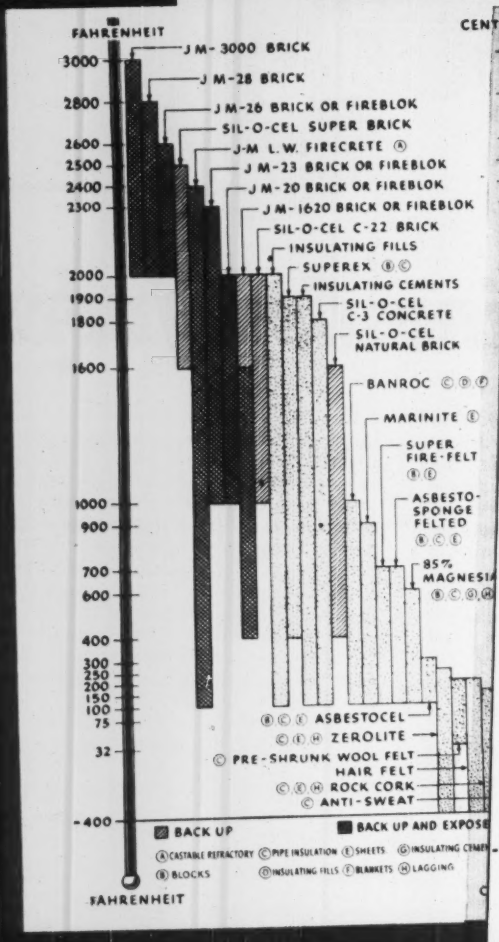
BALDWIN·REX *ROLLER CHAINS*

a complete line from ¼-inch to 2½-inch pitch

BALDWIN-DUCKWORTH DIVISION OF CHAIN BELT COMPANY

Ready reference chart...

Johns-Manville THERMAL INSULATIONS



FOR EVERY TEMPERATURE JM EVERY

Yours... for better insulation service!

Now, you can see at a glance the recommended insulation for every temperature range, from minus 400F to plus 3000F.

It's all on this convenient Johns-Manville Thermal Insulation Chart (11½" x 18") available for hanging in your office or on your plant wall.

Each insulation in this group of Johns-Manville products is tailor-made to do a specific type of job *best*. And, as part of the Johns-Manville Insulation Service, specialists are available to help you with present insulation problems . . . or with those connected with future plans.

By having these men select and apply Johns-Manville insulations, you will be dealing with men who have grown up in the business. You'll find that it will pay, in the long run, to have these experts help you... *because they have to their credit more man-hours of insulation application experience than all other similar types of organizations combined.*

For your copy of this chart, just fill in and mail the coupon below.

Johns-Manville
Box 290
New York 16, N. Y.

Please send me copy of Johns-Manville Insulation Chart IN-6D.

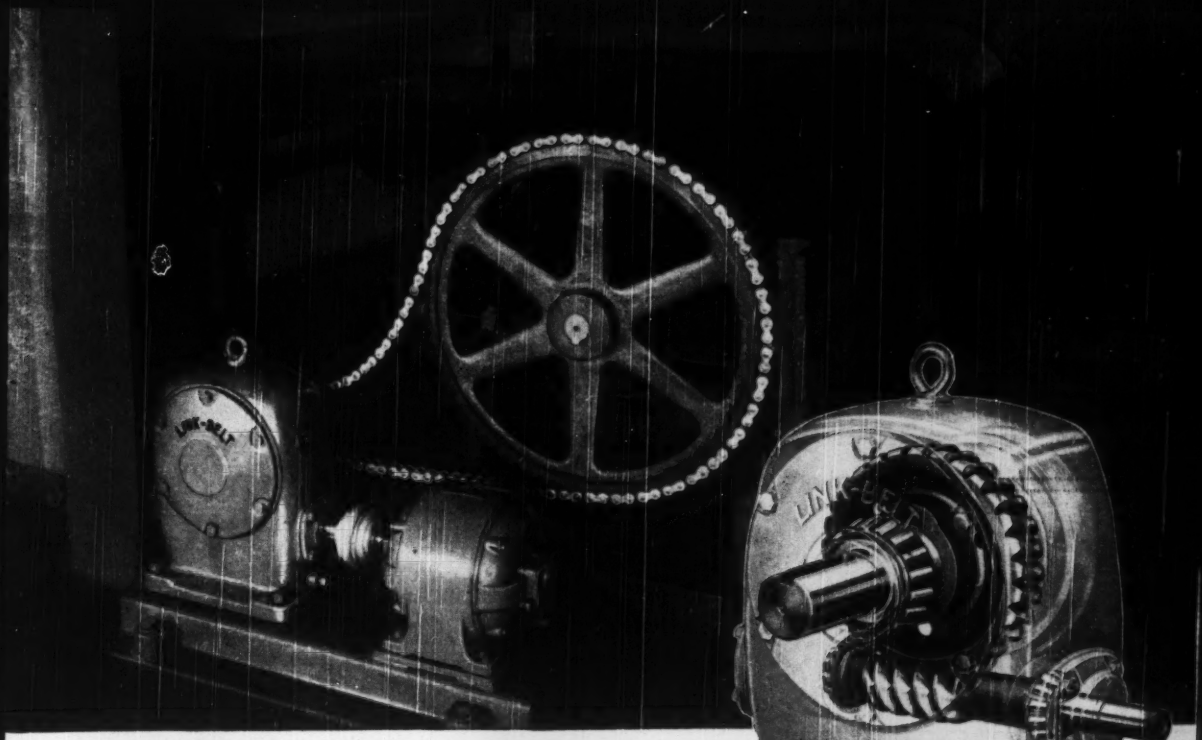
Name_____

Title_____

Company_____

Address_____

City_____ State_____



If the problem involves Speed Reduction

LINK-BELT experience may help you..

Any application for a speed reducer can be filled with a Link-Belt enclosed gear drive—and satisfactory results assured. Link-Belt manufactures all standard types, and Link-Belt power transmission specialists can offer reliable recommendations as to size and type to suit your precise need.

Herringbone Gear Drives for large reductions in limited space—high shock resistance—single, double or triple reductions. Send for Book No. 1819; Worm Gear Drives for high ratio reductions, horizontal or vertical drive shafts. Data in Book No. 1824; Link-Belt Gearmotors, self-contained power unit. Book No. 1815-A.

In respect to any drive in the broad Link-Belt line of power transmission machinery, Link-Belt engineering advice is completely unbiased.

TYPES OF LINK-BELT POWER TRANSMISSION MACHINERY

Precision Steel Roller Chain	P.I.V. Variable Drives
Silverstreak Silent Chain	Fluid Drives
Steel and Malleable Chain	V-Belt Drives
Worm Gear Drives	Ball Bearings
Herringbone Gear Drives	Roller Bearings
Helical Gear Drives	Babbitted Bearings
Gearmotors	Couplings, Clutches, Collars, etc.

LINK-BELT COMPANY Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices, Factory Branch Stores and Distributors in Principal Cities.

11,750

LINK-BELT

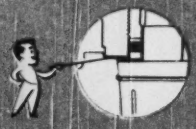
Power Transmission Machinery

"THE COMPLETE LINE"

IN NO OTHER VALVE

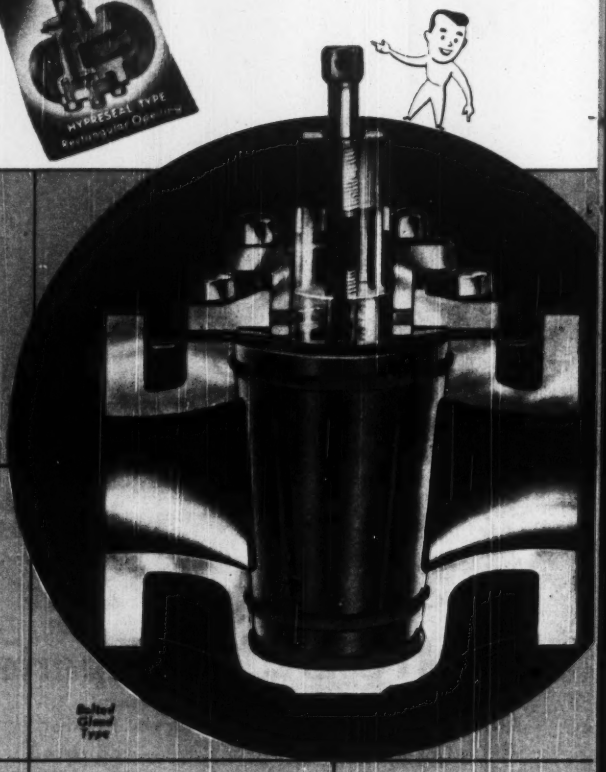
POSITIVE ROTARY ACTION

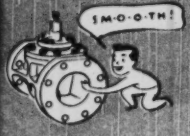
Tapered plug, fully lubricated



RESILIENT SHOULDER STEM SEAL

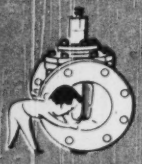
Allows locking of plug





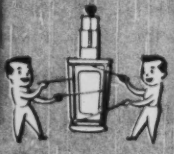
SMOOTH PASSAGEWAY

Streamlined, devoid of crevices



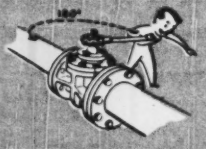
CAN BE "CRACKED" WITHOUT LUBRICANT LOSS

Lubricant will not blow out



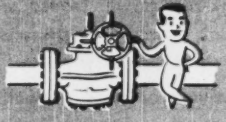
"SEALDPORT" SURROUNDS PORTS

Seals each port against leakage



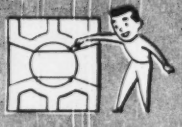
RENEWABLE SEAT WITHOUT REPLACEMENT

Plug can be re-positioned 180°



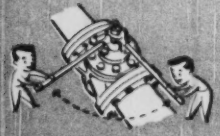
LEAST EFFORT TO OPERATE

Lubricant prevents galling



SEAT OF VALVE NEVER EXPOSED

Line fluid does not contact seat



QUARTER-TURN

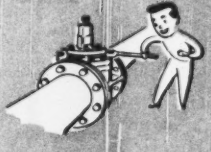
Simple sliding action

MOST COMPACT SIZES

Can be set in restricted spots

RE-LUBRICATED UNDER PRESSURE

Ball check valve holds pressure



ADJUSTABLE UNDER ANY PRESSURE

No need to shut down line

So many features and every one IMPORTANT!

NO BY-PASS NECESSARY

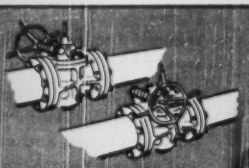
Safe with high differentials

CORROSION AND EROSION EFFECTIVELY RESISTED

Lubricant pressure protects parts

REPAIR PARTS AVERAGE ½ OF 1%

As compared with valve sales



VALVE SETTING IN OPTIONAL DIRECTIONS

Not restricted to one-way flow

A TIGHT SHUT-OFF ALWAYS

Lubricant pressure maintains seal

NO STEM BREAKAGE

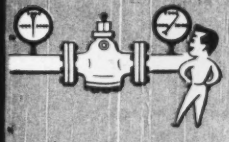
No excessive stress

FULL-FLOATING HYPRESEAL PLUG

Stem is independent of plug

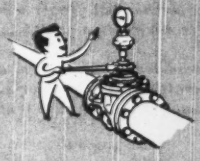
FASTEST CLOSURE IN FRACTION OF USUAL TIME

Can be closed slow or fast



CAN BE OPERATED WITH ANY DIFFERENTIAL

No wedging force to overcome



INTERNAL LUBRICANT PRESSURE CAN BE GAUGED

Gauge can be directly installed

REPACKABLE UNDER ANY PRESSURE

Can be packed in any position

HYPERMATIC AUTOMATIC LUBRICATION SAVES TIME

Self-acting; self-feeding

Nordstrom Valves

NOW AUTOMATICALLY LUBRICATED WITH Hypermatic

Pats. Applied for

Trade Mark

***Nordstrom Valve Division*—ROCKWELL MANUFACTURING CO.**

400 North Lexington Avenue, Pittsburgh 8, Pa., Offices in all principal cities

Export — Rockwell Mfg. Co., International Division, Empire State Building, New York 1

Two metals for the HOT jobs—

INCONEL
INCONEL "X"

Offering exceptional strength and high corrosion-resistance up to 2000° F., these high-nickel alloys solve "hot spot" problems.

With the continuing development of gas-turbine and Diesel-electric power systems, locomotive designers are becoming increasingly interested in *heat-resisting* alloys . . .

Where operating temperatures may soar well past the 1000° mark . . . as in turbine blades, exhaust systems, turbo-chargers, and steam generator fire pots . . . new and serious engineering problems must be solved. At red-heat and higher temperatures, destructive oxidation, accelerated corrosion, and heat-softening become major threats to materials of construction.

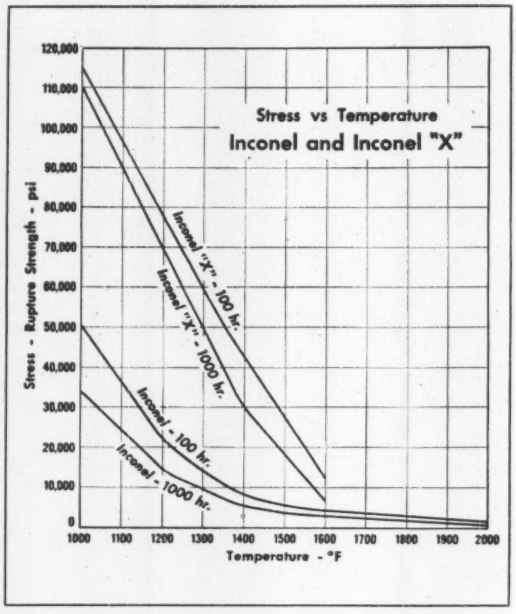
Among the relatively few metals to show satisfactory long-time performance under such severe service conditions are *Inconel*® and *Inconel "X"*®. Both alloys have equally good resistance to destructive oxidation at temperatures up to 2000° F. Both alloys are workable. And both alloys are *practical* in cost.

Inconel serves best where a high degree of corrosion-resistance is required and where moderate hot strength is sufficient . . . as, for example, in exhaust systems, expansion joints, and combustion chambers.

But where "super" properties are needed, age-hardenable *Inconel "X"* should be specified. In addition to a corrosion-resistance equal to that of *Inconel*, *Inconel "X"* offers higher hot strength, particularly in the 1200° to 1500° F. range. Typical applications for *Inconel "X"* are: turbine wheels and blades, structural members, high-temperature springs and fastenings.

In short . . . for applications where its higher cost is warranted, call for *Inconel "X"*. But for most "every day" high heat jobs, specify economical *Inconel*.

If you are concerned with metal specification, your reference files should contain full engineering information about these two heat-defying Inco nickel alloys. Write for it . . . today. And remember, too, that our Technical Service Department is always ready to help you solve metal-selection and fabrication problems.



INCONEL *"X" is age-hardenable and offers exceptional mechanical properties as well as high resistance to destructive oxidation.*

INCONEL *provides an economical answer to most high-temperature metal problems, where moderate hot strength is sufficient.*

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

*Reg. U. S. Pat. Off.

EMBLEM OF SERVICE
NICKEL INCO TRADE MARK **ALLOYS**

MONEL* • "K"* MONEL • "R"* MONEL • "KR"* MONEL • NICKEL • "D"* NICKEL
"L"* NICKEL • INCONEL* • DURANICKEL* • PERMANICKEL* • INCONEL "X"*

MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 72 NUMBER 2

Contents for February, 1950

L. PRANDTL—A TRIBUTE IN HONOR OF HIS SEVENTY-FIFTH BIRTHDAY 116
GUARDING APPRENTICESHIP—OUR PRICELESS HERITAGE . . . . . *D. F. Pratt* 117
DIFFERENTIATING CHARACTERISTICS OF AN ENGINEERING CURRICULUM . . *S. C. Hollister* 122
INSTRUMENT ENGINEERING—ITS GROWTH AND PROMISE IN PROCESS-CONTROL PROBLEMS . . . . . *G. S. Brown and D. P. Campbell* 124
THE OUTLOOK FOR CERAMICS IN GAS TURBINES . . *W. H. Duckworth and I. E. Campbell* 128
HOUSINGS AND SPINDLES FOR ANTIFRICTION BEARINGS . . . . . *H. L. Blood* 131
SELECTING ANTIFRICTION BEARINGS FOR MACHINE TOOLS . . . . . *J. H. Baninger* 134
CHARACTERISTICS OF GREASES AS RELATED TO ANTIFRICTION BEARING APPLICATIONS . . . . . *E. S. Carmichael and R. C. Robinson* 137
MAINTENANCE OF ANTIFRICTION BEARINGS . . . . . *J. M. Bruening* 142
JOB SATISFACTION AND LABOR MOBILITY . . . . . *G. P. Shultz* 145

EDITORIAL 115
BRIEFING THE RECORD 147
ASME TECHNICAL DIGEST 159
CONTENTS OF ASME TRANSACTIONS . 167
REVIEWS OF BOOKS 168
ASME BOILER CODE 172
THE ENGINEERING PROFESSION—NEWS AND NOTES 176
ASME NEWS 186
ASME JUNIOR FORUM 189
ENGINEERING SOCIETIES PERSONNEL SERVICE, INC. . . 196

INDEX TO ADVERTISING PAGES . . . 100

OFFICERS OF THE SOCIETY:

JAMES D. CUNNINGHAM, *President*
J. L. KOPF, *Treasurer* C. E. DAVIES, *Secretary*

PUBLICATIONS STAFF:

GEORGE A. STETSON, *Editor* FREDERICK LASK, *Advertising Mgr.*
K. W. CLENDINNING, *Managing Editor*

PUBLICATIONS COMMITTEE:

R. B. SMITH, *Chairman*
JOHN HAYDOCK G. R. RICH
C. B. CAMPBELL PAUL T. NORTON, JR.
H. G. WENIG, D. R. THOMAS } *Junior Advisory Members*

REGIONAL ADVISORY BOARD OF THE PUBLICATIONS COMMITTEE

KERR ATKINSON—I
OTTO DE LORENZI—II
W. E. REASER—III
F. C. SMITH—IV
HUNDLEY BLACKMON—V
R. E. TURNER—VI
R. G. ROSHONG—VII
M. A. DURLAND—VIII

Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York 18, N. Y. Cable address, "Dynamic," New York. Price 75 cents a copy, $7.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage outside of the United States of America, $1.50 additional. Changes of address must be received at Society headquarters three weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B13, Par. 4). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . . Copyrighted, 1950, by The American Society of Mechanical Engineers. Member of the Audit Bureau of Circulations. Reprints from this publication may be made on condition that full credit be given MECHANICAL ENGINEERING and the author, and that date of publication be stated.

MECHANICAL ENGINEERING is indexed by the Engineering Index, Inc.

L. Prandtl

(A tribute in honor of his seventy-fifth birthday will be found on page 116)

VOLUME 72
No. 2

MECHANICAL ENGINEERING

FEBRUARY
1950

GEORGE A. STETSON, *Editor*

ASME Treasurers

THE American Society of Mechanical Engineers has been fortunate in its treasurers. The gag about the treasurer who asked his visitor to look him in the eyes and tell him which one was made of glass does not apply here. For the four men who have held the post in the last sixty-five years are remembered with affection and respect.

Major W. H. Wiley was treasurer from 1884 until his death in 1925. During his years of service the Society passed through important periods of growth and its income increased from $10,000 to nearly $700,000 per year.

Erik Oberg, who followed Major Wiley, served during the ten most difficult years of Society financial history. The qualities that predominate in Oberg's character make him a wise, practical, conservative, and forward-looking adviser in times of adversity as well as prosperity. The shock of the depression which the Society weathered and from which it recovered during Oberg's treasurership, drove income downward faster than commitments for expenditures could be curtailed. Before the ten years were over, the Society was once more operating "in the black," and additions were being made to surplus. Today, Oberg's name is still to be found on the roster of ASME committeemen, and his advice is sought on matters in which his natural qualities and long experience have matured into sound judgment.

W. D. Ennis, who became treasurer in 1935, was a conservative and objective-minded man who instilled sound economic principles in the engineering students at Stevens. The friends who were fortunate enough to share some of his leisure hours enjoyed his humor, his anecdotes, and his keen observations on engineering and current affairs. During his nine years of service, Society accounting procedures were revised, investment portfolios were strengthened with a view to security and liquidity, and surplus "for a rainy day" reached a value of nearly $400,000. Ennis died in 1947, but he had lived to see his policies in operation and an annual Society income of more than $700,000.

K. W. Jappe, who took up the task laid down by Ennis in 1944, had been influential in establishing the fiscal policies under which the Society worked its way back to financial stability after the depression. When he relinquished his post last December after five years of service, the goal of a half-million-dollar surplus had been reached and income had exceeded a million dollars. Living at the Engineers' Club in New York, Jappe was in daily contact with Society headquarters and possessed an intimate knowledge of the policies and operations of the Founder Societies, the Engineering Societies Library, and the United Engineering Trustees, as well as ASME.

Jappe is one of those rare individuals whose approach to problems is governed by sound principles to which his mind is tenaciously attached. His hardheaded economic philosophy, which carried him through a successful business career, was frequently expounded by him to engineering students, to the ASME Finance Committee and Council, to the United Engineering Trustees, and less formally to his luncheon companions at the Club.

That group of Jappe's friends got to know another side of his character, a human and constructive quality, a depth of homely wisdom, and a keenness of perception not always associated with hard-shelled conservative treasurers. In the rough and tumble of frank discussion of every subject under the sun it is only the tone of the voice, the good-natured laugh, and the mutual respect and understanding of friends that soften criticism. In such an atmosphere and among such companions, the critic inevitably talks himself into a job. Such was Jappe's experience. But to his credit let it be said that he took on those jobs, one after another, and did something about them. There resulted a search for facts, a clear analysis of the situation, a soundly reasoned argument, and recommendations in simple language in a written report. In 1949 he let it be known that he would not accept another term as treasurer; and, his successor appointed, he started south, leaving his friends to hope that he will soon return.

With the appointment of Jos. L. Kopf as ASME treasurer, the Ennis-Jappe influence is fortunately continued. Mr. Kopf served on the Finance Committee for seven years and shares with Jappe the philosophy of realism which that committee has developed over the years. Members who were present at an ASME Annual Business Meeting several years ago will remember his dramatic presentation of the report of the Finance Committee. Casting the printed document aside he spoke with intense feeling not about dollars but about the men and their works that the report represented but did not mention. Such enthusiasm and comprehension of values, combined with sound principles and astuteness, are rare assets for ASME.

Associated with Mr. Kopf will be Edgar J. Kates. Two decades of service to the Society have shown that Mr. Kates has an alert and constructively active mind and a high sense of obligation to work tirelessly at every task. He insists on understanding the details of every proposition put before him, and once convinced, he acts with intelligence, energy, and loyalty.

ASME has indeed been fortunate in its treasurers.

L. Prandtl

A Tribute in Honor of His Seventy-Fifth Birthday

IT IS a well-known fact that much of the rapid development of engineering in this century is due to systematic research in fundamental fields. One of the sources from which this research-mindedness sprang is the University of Göttingen in Western Germany, and one of the prominent leaders in applied mechanics, Ludwig Prandtl, will celebrate his seventy-fifth birthday on February 4.

In view of Prandtl's world-wide authority and of the importance of his work to this country, a short survey of its high lights is presented here.

Prandtl's first papers were devoted to problems of elasticity. In his thesis in 1899 he formulated the previously unknown problem of lateral instability in bending. He gave its solution for rectangular cross sections and developed the method of adjusting the test specimen in buckling experiments in such a way that minor imperfections of form and eccentricities of loading were balanced against each other. This method has since become a standard practice.

In his second paper he studied torsion stresses in a bar of constant, but arbitrary, cross section and discovered the soap-film analogy. It shares its intuitive appeal with the older hydrodynamic analogy but proved to be of greater practical value for the numerical evaluation of torsion stresses; and many pieces of soap-film apparatus have been built in the 45 years elapsed since Prandtl's paper.

In 1905 Prandtl wrote the paper that made him famous. His treatise on the motion of fluids with extremely small viscosity removed the seemingly hopeless disagreement between the mathematical and the experimental side of fluid mechanics by showing the mechanism of the boundary layer. It made clear how the very small internal friction of fluids such as water and air may act through the boundary layer, lead to its separation, and thus bring about radical changes in the whole flow pattern, which previously could not be explained by any rational method. The important consequences of Prandtl's boundary-layer conception are well known to all aeronautical engineers.

After his initial success in fluid mechanics, Prandtl's interest was for some time almost exclusively devoted to this field. He took a leading part in the development of airplanes and airships and built a small wind tunnel, the first one in Germany, and the model for many later tunnels built in Germany and in this country. An increasing number of students, engineers, and physicists gathered about him, attracted by the young and original university teacher and the laboratory growing around the wind tunnel. Within this group a good deal of the Göttingen spirit of applied research was hatched which established so close a connection between science and industry. Since that time Prandtl has received and probably still receives many letters from engineers who ask for his advice; and some of the questions brought up by them have led to very valuable investigations, demonstrating again and again the usefulness of fundamental science for the daily needs of engineers.

The second major achievement in Prandtl's aerodynamic research is represented by a group of publications on airfoil theory appearing in 1918 and 1919. There he treats a real engineering problem, that of the spanwise lift distribution on airplane wings. His results had a very visible influence on the appearance and the efficiency of airplanes. They swept away the cutouts so often made before, and did away with many a quaintly shaped type of wing. The working out of the details of his theory and the development methods for its practical applications have kept many brains busy and produced a vast amount of literature.

In the following years Prandtl's scientific activity gained a great breadth. From time to time he returned to the problems of elasticity and made valuable contributions to the young theory of plasticity. He played a leading part among the investigators of the turbulence problem, studied the turbulent flow in pipes and the turbulence of the natural wind, and formulated the idea of the mixing length which helped to explore the turbulent zone on the surface of free jets. His special interest was devoted for many years to the transition from laminar to turbulent flow, about which he instigated a series of dissertations. When the theory of compressible flow became of aeronautical importance, he resumed his studies on this subject, established simple relations between incompressible flow and flow at low Mach numbers, and created a new airfoil theory applicable to wings in a compressible fluid.

It is no wonder that with such a vast activity Prandtl gathered more and more pupils around him. Most of them were young men, staying for some time and then going to many parts of the world. Several of them are in this country and some have founded schools of their own, spreading Prandtl's work and adding original contributions to it. Thus his scientific influence reaches indirectly many young engineers who have never seen him but know his papers.

It is no wonder, too, that his ever-growing laboratory and his knowledge were exploited by the dark forces which came to power in his country. They cast many a shadow over his life; and those who lived in those times with him will never forget that he gave a chance to many who otherwise might have been crushed by the millstones which began to grind the country.

On his seventy-fifth birthday the thoughts of many men will be with him in this country and abroad, all wishing him many happy returns of the day.

GUARDING APPRENTICESHIP—OUR PRICELESS HERITAGE

By D. F. PRATT
DIRECTOR OF TRAINING,
THE CINCINNATI MILLING MACHINE CO.

I HAVE been introduced as the Director of Training, but I prefer to feel that rather than being a Director of Training, I am a guardian—guarding our priceless heritage—apprenticeship. For apprenticeship is the heritage of the ages. From the beginning of man, apprenticeship has been the principal means by which he has perpetuated all of his skills and knowledge. From early apprenticeship practices has come much of our formal educational systems. It has been the principal source of the basic philosophies and almost indispensable skills and traditions that have made possible the arts and crafts leading to our present standards of living.

In an industry such as ours apprenticeship is recognized as the means for keeping unbroken the long chain of experiences that are so important to the prestige and success of a company. It is recognized as the means of lending purpose and direction to a young man's life. It is recognized as a principal source of that valuable commodity, "esprit de corps"—for the continual training and injection of fine young blood into an organization can bring with it a great deal of enthusiasm and disregard for adversity. Enthusiasm is like a fluid—it flows from person to person; it can be induced to flow most prolifically from the young. It rejuvenates the old and refreshes the weary.

Having committed ourselves to these principles, it follows that we have great responsibilities in the recruitment and training of young men. I believe that the greatest single influence in the development of a young man's character, outside of religion, is the environment and incentive he finds in his work. Therefore we industrialists must devote a considerable portion of the time we are normally accustomed to spend with materialistic subjects, such as, budgets, deliveries, engineering, manufacturing techniques, and the like, to the training and growth of our people. Some companies are trying to do this training job with a few highly trained people; we believe that it must be shared by a great many throughout the organization, although without a doubt, a few highly trained people serve as a key to the situation. These responsibilities are not easily accepted by many industrial people in that they have devoted most of their adult life to production problems. I will give you our recommendations for making more people in your organization training-conscious. We believe that we have enjoyed considerable success in solving this problem.

WHO IS RESPONSIBLE FOR TRAINING?

In our case top management has decided that training—being of equal and vital importance to all branches of the company—must be a top-management responsibility. It follows that every important division must be tied into the training plan. Therefore a Training Committee, appointed by top management and composed of all principal operative heads throughout the company, serves as a board to assist the training director in matters of policy—selection, training, and counseling. The members of the committee are as follows. Vice-president and general manager, *chairman*; vice-president and assistant general manager, *vice-chairman*; vice-president in charge of sales, manager of a subsidiary division; works manager, personnel director, chief of sales engineering, chief engineer, production manager, plant superintendent, foundry superintendent, and training director.

These men aid in interviewing, selecting candidates, making up curricula, policy making, placement, and numerous other duties connected with a virile training program. They are constantly being called upon for various assignments such as the organization and administration of class programs, counseling, and the like, so that they never lose sight of the fact that they, too, are responsible for the training of our young men. This process opens to the training director all of the splendid facilities of our company, the great variety of talents and abilities, and ties the entire organization into training responsibilities.

WHAT ARE OUR RESPONSIBILITIES TO THE BOY?

Let us first examine our responsibilities when we subscribe to the recruitment and training of young men. Let me repeat that it is my sincere belief that the jobs and training that we give our young men not only develop their abilities but have as much to do with the refinement of their personalities, rounding out character, developing resourcefulness, as any other single factor except religion.

I am sure that most of us have seen evidence of Christian thought somewhat distorted by job unhappiness and job influence. Suppose we spend a moment thinking about these responsibilities to the boy that we must share with his parents, his schoolteachers, civic organizations, and the church, accepting the fact that ours may be the larger share. They are as follows:

1 Early in life he must develop a healthy wholesome attitude toward his life, his government, his work, and progress in general.

2 Early in life he must develop useful abilities and work habits.

3 In the same manner he must acquire a sense of responsibility.

4 He must acquire a sense of usefulness.

5 He must acquire a sense of purpose and direction.

6 He must see the need in organization for rules and regulations.

7 He must have an appreciation of discipline.

8 He must learn to put a high value on loyalty and integrity.

9 He must meet many kinds of people and learn to work with all of them.

10 He must acquire satisfaction in the dignity of his work and position.

Some old timers argue that all of this is attitude, but I am not so sure. In my Boy Scout work I have seen many 12- and

Contributed by the Education Committee and presented at the 1949 Fall Meeting, Erie, Pa., of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

14-year-old children who had fine attitudes but few of the other qualities. Many people say that good or bad attitude begins in the cradle, but nearly everyone agrees that it is developed chiefly by early environment. I share these views generally, but also take the stand that good job influence and job happiness during a boy's most impressionable years are the prime movers that make for enduring good attitude. Attitude seems to stimulate or retard, as the case may be, the proper development of the nine other characteristics I have just mentioned. It is true that attitude is an abstract word but it is a mighty convenient one to use!

WHAT ARE OUR RESPONSIBILITIES TO OUR COMPANIES?

Even though I have emphasized our responsibilities to our youth, I must not let you believe that it can take precedence over our responsibilities to our companies. The growth of industry has brought with it new needs in the way of trained men. No longer can a leading company escape being trainingwise. Our growth and reputation are dependent upon the skill, integrity, resourcefulness, and wholesome philosophy of our people. Business can no longer wait for leaders and trained people to happen; it must make them happen.

HOW SHALL WE MEET OUR RESPONSIBILITIES?

Having in mind these two definite responsibilities that are a must in our training, I would like to give you our recommendations as to how they can be met. The first step has to do with *pride* in everyone who works in the plant—pride in his job, pride in his company, pride in his training.

THE KEY TO THIS IS TO DIGNIFY LABOR

As many of you know from personal experience, most mothers (and dads too) are ambitious that their boy should graduate from college so that he may become a doctor, a lawyer, a judge, a statesman, or other similar public figure. The thought of having him enter a shop has not been too well received. It is believed that one of the reasons for this is that we of industry have failed to dignify labor—to dignify apprenticeship so that the finest young men may be attracted to it. Perhaps if we had done so down through the years some of us would not now be suffering so acutely from labor complications.

The first step to dignify labor is a clean, orderly, and sanitary plant, both externally and internally. Tools, work processes, and quality standards should be planned so that the prideful workmanship is voluntary.

I feel that we do not need to discuss these things in detail; every business executive knows how to do it. My only recommendation is to look about you to see if you are doing it as well as you can. This will make your community and city proud of your plant and will attract higher-type candidates.

SELECTION, TRAINING, AND PLACEMENT

I do not intend to discuss any of these in great detail except to point out unique features that may be of interest to you. Many of you may be much better qualified than I to speak on conventional practices so I will try to talk principally about practices that we have developed over a long period of time that are somewhat unique.

SEVEN-POINT SELECTION PROCEDURE

Our selection procedure is composed of seven basic steps as follows:

1 Natural selection.
2 Preinterview check.
3 Adequate battery of intelligence, aptitude, and psychological tests.
4 Well-planned, nicely conducted interview.
5 Physical examination.
6 Probationary period.
7 Final interview with training committee.

NATURAL SELECTION

I have already discussed some of the things that cause young men of good character and good breeding to be attracted to our industry. We believe that boys of certain interests and abilities will naturally gravitate toward us. Natural selection is induced by the following:

1 People coming in contact with our machines and equipment.
2 Regular contacts that we make with high schools and colleges, to acquaint them with the needs and opportunities in our business.
3 Enthusiastic employees and enthusiastic supervision.
4 Annual open house for our employees.
5 The house organs mailed to the homes of our employees and passed on by them to friends and neighbors.
6 Sons of employees—outstanding boys are frequently attracted to us through the work of the father.
7 Normal effect of our prestige and integrity on the public.
8 Guided tours for university and high-school seniors.

Through these avenues come people who by the law of natural selection have some qualifications deserving our consideration.

PREINTERVIEW CHECK

Each candidate is asked to write a letter in his own handwriting giving full particulars about himself. He is also asked to submit a transcript of his high-school record showing the subjects taken and the grades received, together with any test scores he may have taken in school. He is also asked to submit any references or letters of recommendation that he may be able to obtain, especially from his high-school principal, the pastor of his church, businessmen, and other similar responsible people. All of this, together with a photograph and other interesting material, is mailed to the training director before the boy is called for an interview.

Usually considerable checking is done with the letter and references before the interview. There are times when a visit is made to the boy's home before inviting him to come to the plant for the interview.

ADEQUATE BATTERY OF INTELLIGENCE, APTITUDE, AND PSYCHOLOGICAL TESTS

I do not intend to discuss testing in detail except to point out that we are using it as an aid to interviewing. We have found that there is a definite correlation between intelligence, aptitude-test scores, and job success. We are conducting extensive research in the field of testing. We are using tests that have been recommended by leading psychologists. Some of our people at the mill have attended the Purdue Personnel Testing Institute, which, by the way, we believe to be a fine program for those who are interested in good selection guidance.

THE INTERVIEW

The fourth part of the selection step is the interview. We definitely believe the interviewer should be a person having considerable experience in the field for which he proposes to select people. He should be especially adept in dealing with people. He must have good knowledge of psychology and the needs of his plant. He must be able to draw out of the applicant evidence of ability, good breeding, and leadership capacity.

He should also be able to inspire the candidate with faith in the company and the people for whom he proposes to work.

The interviewer must reflect some of the personality of the company and satisfy the dignity of the applicant in his importance as an individual.

We believe that the impressions made on the boy by the interviewer are important beyond value whether the applicant is accepted or rejected. The applicant must always feel that he has been fairly treated. The success of many of our people often dates back to the spark that was kindled during the interview. I am sure that each of you thinks back with pride and warmth toward the people whom you first contacted when you became associated with your employer.

Interviewing technique is a subject in itself and any detail would require a separate lecture so I will dispense with it by merely saying that we place a great deal of faith in a well-planned interview conducted in a pleasant atmosphere. If we were forced to choose between testing and interviewing, we would throw out the tests.

PHYSICAL EXAMINATION

This examination gives us the opportunity not only to evaluate the apprentice physically and mentally, but also to acquaint him with the services that are available in the medical departments. Our medical personnel must share the responsibility of his employment and training to the following extent:

1 To counsel in all matters pertaining to his general health and hygiene, including safety practices.

2 To recommend limitation of his employment when such is deemed necessary.

3 To assist the out-of-town students in orienting themselves to their new environment, particularly as it pertains to dietary habits, rest, exercise, and social adjustment.

The physicians in the medical department recognize the great investment the company has in each apprentice, and therefore make reasonably certain that he meets the optimum medical requirements to justify this expense.

PROBATIONARY PERIOD

The sixth part of our selection procedure is the probationary period during which the candidate is placed in our segregated training department and frequently shifted from one trained instructor to another who measure his real ability by giving him real tasks of all sorts. The assignments range from cleaning and painting to operating simple machines. Rating sheets are made out for each step of the trial period. Short quizzes are given periodically.

At the end of the probationary period we believe that we have one of the most complete comprehensive appraisals that anyone is able to get of any young man before he is accepted for full employment.

FINAL INTERVIEW

The candidate is now ready for the seventh step or final interview with our Training Committee. We usually have five or six of our executives present at one time who are members of the Training Committee. Up to this time we have been rather easy on the boy. The entire period has been spent trying to discover his native abilities, something of his temperament, integrity, capacity for work, how he walks, how he talks, how he stands, and something of his home training.

In presenting him to the committee we have a definite purpose in mind. We want to leave an impression on the boy that will last for a long time, perhaps all of his life. I know that the boys who have faced our Training Committee during the past twelve years have never forgotten it. They remember the event as being one of the most unusual and unique experiences in their lives. It is true that they are somewhat apprehensive but no more than we expect. It is time to make them think seriously, to impress them with the fact that we mean business and that we are playing for keeps. Some of the boys call this the "sweating-out" period. The members of our Training Committee who participate in the interview are fully aware of what the boy is going through emotionally and make allowances for it. The belief is that some of the very best and the worst in the boy will come out during such an ordeal.

The interview doesn't take very long. At one sitting, the Committee usually takes on five or six boys, one at a time. The boy's record is presented and discussed with him frankly as to whether he has chosen the right thing and whether he is qualified to go forward with his training. If the Committee votes in favor of the boy, he is permitted to enter training under an indentureship.

Just as ballast stabilizes a ship, so does this final interview session tend to stabilize the thinking of many of our boys.

PRELIMINARY TRAINING IN SEGREGATED SCHOOL

We have segregated the basic training from the main shop. The reasons for this stem from the age-old problem of trying to get foremen and the old timers in the early days to give the boys real jobs to challenge their abilities. I do not want you to believe that good men were not trained in those days—quite the contrary—the requirements were not so high as they are today. Present-day requirements are not only tremendously increased but we are also forced to get more for our training dollar.

Many of us who were in supervision a number of years ago were guilty of exploiting the apprentice by putting him on all sorts of odds and ends of jobs, rather than taking the time to give him real instruction on complicated setups and allowing him to perform complicated manufacturing operations. If at rare intervals we did break a boy in on such work, we were very reluctant to change him. Therefore it was frequently our practice to keep him on such work a long time rather than to move him along to other phases of training. In our own case, it was finally decided to take out of the shop the machines that we wanted our boys to run and to take along with them the best type of foreman for instruction, and last, but very important, to take out of the shop the type of work that we wanted to use for the training of boys. By placing all of this in one department we were assured that the boys would do the work and would receive proper instruction under consistent training policies and objectives. The results have been very gratifying and we have found that a fine young man having good intelligence and good aptitude can easily and quickly adapt himself to complex work assignments. They like to show that they can do the work quickly and often better than some of us who try to set the pace.

Our segregated school regularly manufactures approximately one thousand detail parts for milling, grinding, broaching machines, and attachments, as well as hundreds of customer repair orders, special machine parts, tools, and maintenance repair parts. We also manufacture and assemble many types of machine-tool vises, machine-tool attachments, lubricant pressure pumps, valves, simple fittings, and the like. A great number of jigs and fixtures have been made, repaired, or altered. Special projects from the engineering department have frequently been completely made in the school. Quality standards are exceptionally high. Eighty machine tools are in the school along with numerous accessories and equipment. Our manufacturing, tool, and assembly departments have a capacity of about 125 boys.

THE ACHIEVEMENT TRAINING PLAN

I would like now to talk about a method of training that differs widely from what most plants are doing. I will describe

it in detail. It was designed simply because we recognized the fact that some boys have greater capacity than others. It is simply as follows: Whenever a boy enters any phase of our training he takes with him a requirement sheet for that phase of the training. The requirement sheet has listed upon it the things that he must cover during his stay in the department.

Many of you will remember how some of us were trained many years ago. Often, one of the principal thoughts in a boy's mind was to keep out of sight. Frequently the more gullible boys were victims of a wide variety of practical jokes such as chasing left-handed monkey wrenches, arbor stretchers, and salamagoosala oil. I know that many boys were confused and completely uninformed about what they should learn while in the department. We have provided a clear-cut road map for the boy. The finest of modern equipment has been provided for his use, in addition to the type of work and instruction he needs. The requirement sheet clearly sets forth the tools, machines, and work processes with which he must become familiar. The requirement sheet does not answer his questions; he must learn by doing, by asking, by attending classes, by reading. All of these facilities have been made available. A maximum and minimum time limit is specified on the sheet. At the end of the minimum time he may, with the permission of his instructor, apply for an examination. If he does not ask for the examination between the minimum and maximum time, we give it to him at the end of the maximum time. If the examination and instructor's rating are satisfactory the apprentice is rewarded with an increase in pay and starts the next phase of the Achievement Plan.

Two forms of incentive are evident in this plan:

1 If he completes each phase of his training within the minimum time limit, he is able to complete his basic apprenticeship training in $3^1/_2$ instead of 4 years.

2 If he completes it within $3^1/_2$ years he is able to get his earnings up to the 4-year rate in $3^1/_2$ years.

We do not graduate any boy at the end of three and one-half years, but we give him an additional one-half year of merit training, during which time it is possible for him to get two more increases in pay. We believe that any boy who can complete his apprenticeship in three and one-half years is a very good candidate for higher responsibilities. Strict requirements have been established for each phase of training.

During all of this time the apprentices are attending either the University of Cincinnati or the Ohio Mechanics Institute evening school two evenings a week, studying the basic work in mechanical engineering or other courses, depending upon the type of apprenticeship. They are also given approximately three hours of classwork each week on company time, pertaining to practical problems in the shop. In order to discover leaders and give leadership training, the boys are frequently given assignments wherein they are required to talk before their respective groups. The older boys frequently conduct sessions for the younger boys. They help with many of the programs and carry on a variety of interesting activities in connection with their apprenticeship.

COURSES OF TRAINING

I will not discuss in detail the many programs we have in that they are similar to those given in other industries. Roughly, twenty types of candidates are accepted for training in different programs as follows:

8000-hour regularly indentured machine-tool apprenticeship.
8000-hour regularly indentured pattern-shop apprenticeship.
8000-hour regularly indentured electrical apprenticeship.
8000-hour regularly indentured metal-fabricating apprenticeship.
8000-hour business-training program for high-school graduates.
6000-hour mechanical-drafting apprenticeship.
Two-year training program for co-operative mechanical-engineering college students (actually $4^1/_2$ years total time).
Two-year training program for co-operative electrical-engineering college students (actually $4^1/_2$ years total time).
Two-year foundry-training program for co-operative engineering-college students (actually $4^1/_2$ years total time).
Two-year training program for co-operative chemical and metallurgical-engineering college students (actually $4^1/_2$ years total time).
Two-year training program for mechanical-engineering college graduates.
Two-year training program for industrial-engineering college graduates.
Two-year training program for electrical-engineering college graduates.
Two-year foundry-training program for engineering-college graduates.
Two-year training program for chemical and metallurgical-engineering college graduates.
Two-year training program for liberal-arts, commerce, business-administration college graduates.

INTERVIEWS WITH EXECUTIVES AND OPERATIVE HEADS DURING LAST YEAR OF TRAINING

During the last year of apprenticeship we again have found a means of tying in not only the members of our Training Committee but a large number of responsible people throughout the organization. Every boy is scheduled for an interview once each week with some department head or executive. Each executive and department head has agreed to set aside a few minutes every Friday morning to see a boy. This has proved to be a very wonderful process as far as we are concerned. We give the boy his schedule of interviews and tell him that he must make the contacts by phone to see if he can meet with the department head or executive at the appointed hour. If the executive finds that it is not possible to meet the boy at that time, they arrange another appointment between them. The only contact the Training Department has is to schedule the interview and to mail the executive a résumé of the boy's record prior to the interview. We have had such success with this plan that we heartily recommend it to all of you who are engaged in the training of men. The boy gets a tremendous lift out of it and the executive gets an opportunity to meet and talk with the young people. They often take the boy on a short trip through their departments so as to see at firsthand the work that is being done. The executive returns a form to our department indicating some of the high points of the interview and his recommendations for eventual placement of the boy. In this manner the boys get to meet and know our leaders and, conversely, the executives get to know the boys who will soon become a permanent part of the organization. This process gives the boy a feeling that he belongs—that he is important. It forms a bond that is very difficult to break. This is the real beginning of placement. In nearly every case the boy finds among these men a department head with whom he would like to work and an opportunity further to develop his natural talents together with the knowledge and skills he has acquired. It has been our experience that the executives get just as much out of it as the boy. All of the executives are continually kept informed of interviewing techniques and policies so as to maintain a reasonable degree of consistency.

GRADUATION

Upon graduation from the four-year programs, apprentices

receive a certificate from the company, a certificate from the National Machine Tool Builders Association, and $150 cash bonus. Graduates from the two-year programs receive a certificate from the company.

TWO-YEAR FOLLOW UP

It is the responsibility of the training department to follow every graduate for a period of two years. Every three or four months the training director checks with the department heads regarding the ability, capacity, and potential of the boy who has been placed in the department. It is the responsibility of the training director and the Training Committee to report to management regarding outstanding men. It is also the responsibility of the training director to check the rate of pay of the graduates—to compare it with the going rate for the job and to initiate increases that will assure the graduate a rate of pay commensurate with the job that he is doing.

This process prevents having good men buried in obscure positions and helps to tie the graduate to the company.

It should be mentioned that the Training Department and the Training Committee retain a permanent interest in the proper placement and success of the graduate.

Our success with this formal procedure makes me want to heartily recommend it to you.

DOES IT PAY?

The most frequently asked questions in respect to training are: How much does it cost? Does it pay?

Nearly all of our technical and leadership positions are filled with men who have had extensive practical training of some form or another in our organization. Formal apprenticeship has become a must with us for a great many years.

HOW MUCH DOES IT COST?

There are three ways of looking at the cost:

1 If we compare the productive benefits of apprenticeship with standard shop costs—apprenticeship is quite expensive.

2 If we compare the cost of the products which are produced by our apprentices in our segregated training department with the standard selling price—we come out a little ahead.

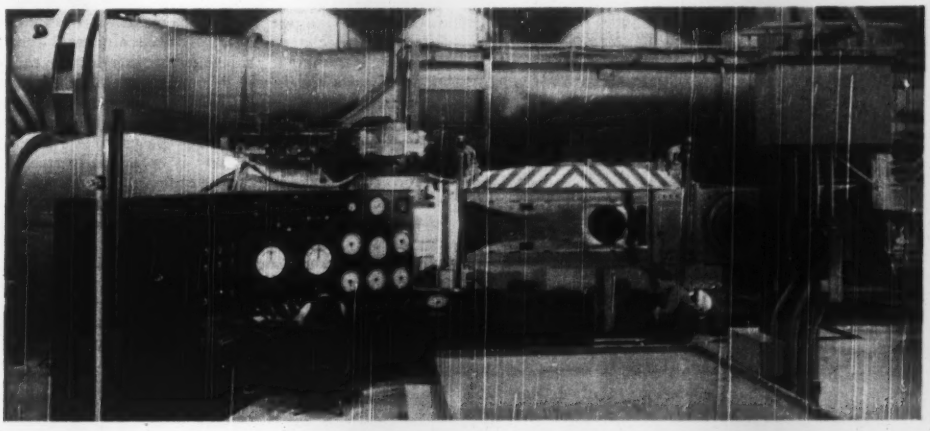
3 If we were to survey the worth of fifty outstanding men who have graduated in the last twenty years, we are certain that we would be able to establish a figure that would be greater than the actual cost of all training since the beginning of the company.

After all, isn't that what we are after?

THE BARGAIN COUNTER OF LIFE

We have talked about selection, training, programs, examinations, and related subjects. In closing I do not want you to lose sight of the moral responsibility that industry has in preparing young men for their lifework. Everyone who is in any way connected with apprenticeship is fortunate in being able to stand at the bargain counter of life and watch the wonderful process that goes on. Every young man at some time in his life must approach this bargain counter and lay on it the things that he is willing to trade for what he wants out of life. Usually he is not fully aware that this important process is going on. Often his immediate desires are more important to him than long-range planning. Therefore his reactions at the bargain counter have to do with natural initiative, immediate desires, and home training. A great deal of wisdom is required on our part to make sure that good decisions are made that may set the whole pattern of his life. If he wants money, he will approach the bargain counter with shortsightedness, selfishness, sometimes conniving and outright dishonesty. If he wants happiness alone, he may approach the bargain counter with simple philosophies and good work-a-day habits that will give him a good name among his neighbors and associates. If he wants position, prestige, happiness, and money, all in one, he must lay on the bargain counter integrity, loyalty, sincerity, hard work, good habits, willingness to study, good morals, and a fine personality.

All of us are in a position to do great things at this bargain counter. Let us discharge our responsibilities with all of the dignity and wisdom at our command and guard the priceless heritage that is ours by keeping apprenticeship on the high plane that it belongs.



GENERAL VIEW OF THE WIND TUNNEL IN THE NAVAL SUPERSONIC LABORATORY AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

(Observations of models in the high-speed air stream are made through a circular window in the cover of the test section in the center of this picture. Operating conditions and results are recorded by equipment behind the lower ports, over which the technician is bending. The wind tunnel, largest in any American University, was built at M.I.T. under the auspices of the Navy Bureau of Ordnance.)

Differentiating Characteristics of an Engineering Curriculum

By S. C. HOLLISTER

DEAN OF ENGINEERING, CORNELL UNIVERSITY, ITHACA, N. Y. MEMBER ASME

THERE has been a steady increase in specialized branches of engineering during recent years. Some of these are simply specializations in functional engineering, such as welding engineering, tool and die engineering, petroleum engineering, and refinery engineering. Others are associated more closely with the basic sciences, as, for example, geological engineering or engineering physics. Still others tend toward the border line of business, such as administrative engineering or general engineering.

Many engineering schools have catered to the popular demand for specialized training in a wide variety of engineering specialities. As a result there exists today some confusion as to what really characterizes an engineer, or indeed a curriculum suitable for training for any of the branches of engineering. It appears timely, therefore, to examine this situation and to prepare if possible a compact statement of what characterizes *engineering* training. In fact, if accreditation is to be successful, curricula so accredited must contain such characteristics as may readily identify them as *engineering* curricula.

BOUNDARIES BETWEEN ENGINEERING AND CONTIGUOUS FIELDS

Engineering education is surrounded by other educational operations. It will be helpful to explore the boundaries between engineering and those contiguous fields in order that a clearer understanding of engineering education may be had. It would be hoped that such a process of boundary exploration would eventually so circumscribe the training and function of the engineer as to make it feasible to undertake a direct definition of the characteristics of an engineer.

It is generally accepted that engineering training is at the college level. Thus one segment of its boundaries would be represented by the trade school, the technical institute, and the general secondary school. Within the collegiate area it is bounded by programs in the liberal arts, in science, in business, architecture, agriculture, etc.

Boundaries between college and secondary schools or trade schools are well defined. Similarly, the technical institute operating at post-high-school level is readily distinguished from engineering training at college level. Confusion arises in varying degrees between engineering training and other college work. Particularly it arises in curricula which are in part engineering and in part other college subjects.

It should be stated clearly that this discussion does not undertake to evaluate curricula which are in part engineering and which are heavily charged with work in business, liberal arts, or some other field. Such courses are highly desirable and more of them should be given. The sole problem considered here is whether such curricula should be considered as *engineering* curricula leading to an *engineering* degree. This calls for a specification of *differentiating characteristics contained in an engineering curriculum.*

COMPARISON OF SCIENCE AND ENGINEERING CURRICULA

A comparative study of curricula in science programs with those in engineering reveals a significant difference between the two groups of curricula. It is characteristic of the engineering programs that mechanics, mechanics of materials, and courses in the properties of materials be included. Based upon such courses, it is also characteristic that in varying degree there will be courses relating to structures, apparatus, or machines, and the principles upon which they are designed, constructed, and operated. Such courses are not found in the science curricula. For example, a curriculum in mining engineering will include mathematics, physics, chemistry, and geology, as will also a curriculum in geology. But the mining-engineering curriculum also contains courses in mechanics, hydraulics, hydraulic machinery, heat engines, and electrical equipment. The inference is that the mining engineer is going to design, construct, and operate, and that the geologist is interested in the formation and nature of the earth's crust but that he is not intending to design, construct, or operate works either above or below ground.

When curricula in engineering and in architecture are compared, courses in mechanics and materials and sometimes in structural design are found in the architectural program. The principal characteristic of the architectural curriculum, however, is training to achieve artistic excellence in the proportions of parts and in the decorative treatment of structures. In practice the architect emphasizes function and beauty, whereas the structural engineer emphasizes function and safety. The two fields obviously lie very close together and it is conceivable and, in fact, is occasionally true that the architect may act as a structural engineer, and vice versa.

A comparison of curricula in electrical engineering and in physics reveals the characteristic presence in the engineering curriculum of mechanics and materials of engineering. The physicist ascertains the behavior of physical phenomena in terms of physical principles and, generally speaking, is not concerned with design of machinery and apparatus for manufacturing purposes. The engineer, on the other hand, is applying the principles of physics in the creation of machinery and apparatus for manufacturing or other useful purposes.

DISTINGUISHING CHARACTERISTICS OF AN ENGINEERING CURRICULUM

Throughout these differences of characteristics noted between the engineer and a person in an adjoining field, one finds *ability to design* as a significant and distinctive element. The process of contriving a scheme, system, or concept of a device, together with a forecast of behavior thereof, which if built would be ap-

---

This statement, prepared by Dean Hollister and adopted by the Committee on Engineering Schools of the Engineers' Council for Professional Development, was presented at the Annual Meeting of ECPD in Chicago, Ill., Oct. 29, 1949. It is followed by a discussion by Dean Hollister. Comments on this statement are welcome and should be sent to the Editor, MECHANICAL ENGINEERING.

propriate to the functional, economic, and safety requirements, is here meant as design. An engineer, for example, *designs* a bridge by first *analyzing* the conditions and functions to be satisfied; and secondly, by *synthesizing* from his knowledge of foundations, loadings, construction methods, mechanics, properties of materials, traffic requirements, economic considerations, financing, etc., the elements appropriate to this particular structure.

It may now be stated that:

> An engineer is characterized by his ability to apply creatively scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design, and of the limitations of behavior imposed by such design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation, and safety to life and property.

The function of design is not limited to machines and structures. Process design may be defined briefly as the determination of the best process to accomplish a given end from the standpoint of economy, safety, and available raw materials and equipment. Courses in engineering application, therefore, which supplement those in applied science for full development of design qualifications are not limited to machine or structural design, but include production processes

A curriculum which adequately trains a man to become an engineer must furnish the technical background, and should supply also the general training, for the *process of analysis and synthesis essential to designing*. There is the question, however, as to what may be considered an *adequate* training in the various essential features of the curriculum.

All engineering curricula may be divided into five sections as follows:

1 Basic science (mathematics, physics, chemistry, biology).

2 Applied science (mechanics, thermodynamics, fluid mechanics, aerodynamics, geology, properties of engineering materials, etc.).

3 Applied engineering courses (as, for instance, internal-combustion engines, machine design, structures, industrial electronics, plant layout, etc.).

4 Administrative and managerial (cost control, quality control, industrial organization, labor relations, etc.).

5 General (liberal courses designed to provide a general educational background).

Mathematics, physics, chemistry, and biology are the fields of basic science which form the foundation of engineering training, in amounts appropriate to the particular branch of engineering.

Whether administrative and managerial subjects or courses relating to general educational background are included in the curriculum is not essential to our present study because they do not contribute to those peculiar characteristics which differentiate the engineer from his lay-fellows. These do, however, contribute broadly to development of those qualities of professionalism which characterize the engineer capable of large engineering works, especially when such subjects are reinforced by broad attitudes and inspiration of the teaching staff.

Preparation for any form of design originates in the basic science courses, and is governed not alone by what science courses are included, but also by the depth of such courses and the extent to which they are interwoven into subsequent courses in applied science and engineering. For example, mechanics taught without calculus results in much less design ability than mechanics taught with calculus. Similarly, electrical theory taught without differential equations and Fourier's series develops much less power of analysis and synthesis than would have been the case had these two branches of mathematics been employed. The level of course content, and thus of training, is usually set by the depth of training in the basic sciences and what is equally important, the extent to which these permeate the subsequent courses.

DISCUSSION OF THE FOREGOING STATEMENT

No attempt has been made to describe all of the functions that engineers may perform in the course of the practice of engineering. Instead, the differing characteristics have been sought, by which the engineer's work may be recognized from the work of others. A common definition of an engineer frequently quoted is that he is "one who directs the forces of nature to create useful things." Such a statement would not, for example, exclude the architect or the agriculturalist. Many of the engineer's functions overlap those of others, and thus are not in themselves distinctive characteristics of engineering. The engineer directs men; so do persons in many other professions and callings. He applies principles of economics and finance; so do businessmen and bankers. What is here sought is that characteristic which includes all kinds of engineering but which excludes all but engineering.

It is in part a characteristic of the engineer that he applies scientific principles in design, construction, and operation. This differentiates him from the artisan, who constructs or operates without scientific knowledge. The engineer, furthermore, constructs and operates within the framework of limitations inherent in the design; and to do such constructing and operating he must be fully conversant with the design and its limitations.

It is not an essential that in order to be an engineer one must be engaged in designing. It is essential that a knowledge of design be had, based on the application of scientific principles. Such design is not aimed primarily at aesthetic or functional objectives alone, but, in addition, characteristically includes objectives involving economics and safety. The economic objective in part distinguishes the work of the engineer from that of the scientist or the artist.

It is recognized that the words "design" and "designer" mean different things to different people. They are not here used in the narrow sense usually attached to them in engineering offices, where some are "designing," some "detailing," others "developing," and so on. The whole creative process, extending from the initial conceptual thought to the subsequently refined final plan, is here meant as design. It may be achieved by mathematical or developmental procedures, but it utilizes scientific principles.

There is real danger in undertaking to be specific as to the characteristics desirable in any professional program, because there is the possibility of too literal a translation of such a statement into courses rather than into guiding principles. The Committee is fearful that the mention of design might suggest to some the thought that what is desired is a certain number of credit hours in one or more courses labeled design. This is not what the Committee has in mind. Rather, it hopes that design will be regarded in a broader and more fundamental way, involving the development within the student of original, resourceful, creative ability. Such an achievement results perhaps more from the nature of the teaching than from course outline. It becomes a way of education.

INSTRUMENT ENGINEERING

Its Growth and Promise in Process-Control Problems

By G. S. BROWN and D. P. CAMPBELL

DEPARTMENT OF ELECTRICAL ENGINEERING, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS

GENERAL

THIS paper has been stimulated by our awareness of certain factors relating to the recent advances in one field of automatic control, and our association with people in companion fields. In particular we note (*a*) that the last decade witnessed extensive engineering and scientific activity in the field of positional servomechanisms, (*b*) that the percentage of highly trained mathematicians and scientists which staffed these activities was unusually high, (*c*) that many of these staffs took up work in the control field without prior conditioning on the problems and with only knowledge of basic science to guide them, and (*d*) that technical people who intermingle at the fringe of the professions of servomechanisms and process control discuss many problems that seem common to both fields (1).[1]

For the purposes of this paper it is sufficient to know that servomechanisms are feedback-control systems in which the behavior of the output is a function of the difference, or error, between the output condition existing and the output condition desired. In other words, servomechanisms are error-sensitive control systems. A block diagram of such a system is illustrated in Fig. 1. Servomechanisms are used for such tasks

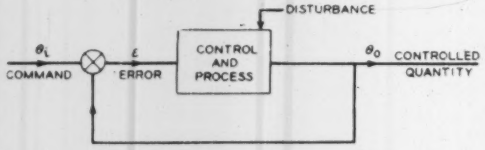


FIG. 1 BLOCK DIAGRAM OF ELEMENTARY SERVOMECHANISM

as the remote control of heavy masses as in gun drives or turrets, for industrial positioning problems, aircraft flight control, stabilization of platforms, and so forth. The fact that the servomechanism is also a follow-up system and usually involves considerable power level increase between the error and the output is immaterial to this discussion.

Because process control, servomechanisms, regulators, or governors are all "feedback" control systems, their basic principles are alike. However, as individuals who have been associated with servomechanism work for about a decade, we sense several barriers to the interchange of ideas basic to these fields. Language and vocabulary make for one. Lack of appreciation of the accomplishments and the difficulties encountered by each group provide another. Lack of unification of the mathematical and experimental techniques used for analysis yields a third. There are others. It is our conviction, therefore, that any opportunity for intergroup discussions of these various problems and particularly the system aspects of these problems, appears highly desirable.

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed by the Industrial Instruments and Regulators Division and presented at the Fall Meeting, Erie, Pa., September 28–30, 1949, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

THE OBJECTIVES OF IMPROVED CONTROL

The role which automatic control plays in industrial programs increases each year in importance. Automatons help sustain mass manufacturing, monitor industrial plants operating around the clock, and help to increase product quality, especially in chemical, petroleum, and the power industries. Although advances have been made in automatic control continuously since the first instrument was used to aid an operator, it appears necessary constantly to consider improvement in control systems to keep abreast of industrial expansion, and constantly to consider the system aspects of industrial design to facilitate control.

Improved automatic control as we wish to speak of it here is the co-ordinated design of plant, instruments, and control equipment. We have in mind more a philosophic evaluation of systems which might lead to the improvement of product quality, to better co-ordination of plant operation, to a clarification of the economics related to new plant design, and to the safe operation of plants in our composite social-industrial community. These general remarks are illustrated by mention that certain industries operating at large production might show appreciable increase in economy and quality on standard production items by improved automatic control. The conservation of raw materials used in a process often prompts reconsideration of control. The expenditure of power or energy in product manufacture is another important factor related to control. The protection of health of the population adjacent to large industrial areas against atmospheric poisoning and water-stream pollution is a sufficiently serious problem to keep us constantly alert for advances in the study and technique of automatic control, not only because of the human aspect but because of the economy aspect.

GROWTH OF CONTROL PRACTICES

Automatic control is a relatively recent innovation. Plants were instrumented originally mainly for metering purposes and to provide accounting data. This practice grew out of the gradual increased production of industries and the need for information on inventories. The continued growth of our industries caused these accounting instruments to become the first phase of closed-loop control. The next phase of instrumentation for industry was the gradual co-ordination of the separate accounting controllers into mechanisms for automatic plant control. Out of this practice grew our industrial-instrument companies and the instrument engineer.

We hear it said that the ultimate effectiveness of the accounting philosophy of control-system design for plants is fundamentally limited. It does not seem to have a sufficiently sound quantitative foundation to keep abreast of the more critical task in the control of product quality (1).

It is our opinion that one should always strive for the most direct approach to the system-design problem, and wherever possible point one's effort toward explicit control of product quality. The problem encountered when a product is controlled in terms of reference quantities may be contrasted with that encountered when the control is explicitly on product

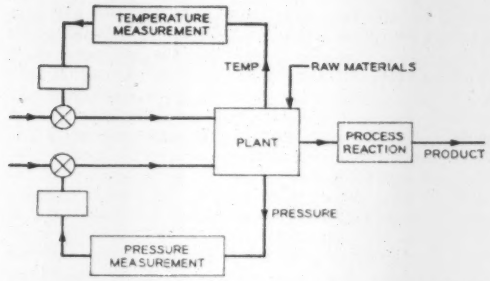


FIG. 2 BLOCK DIAGRAM TYPICAL OF CONTROL WHERE QUALITY IS OUTSIDE THE LOOP

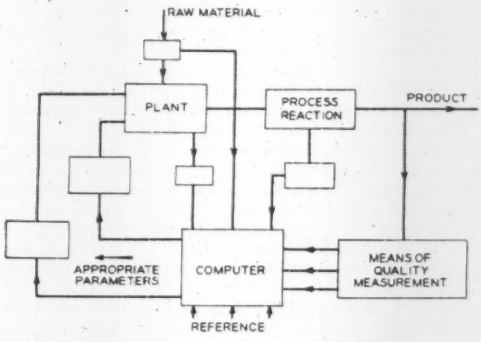


FIG. 3 BLOCK DIAGRAM TYPICAL OF EXPLICIT CONTROL OF QUALITY

quality by a comparison of block diagrams of Figs. 2 and 3. In Fig. 2 the process reaction is not subjected to closed-loop control. The process reaction is outside the loop. In Fig. 3 the process reaction is inside the loop, with the result that quality is subjected to all the desirable features of the closed-loop operation. While this brief paper cannot give specific answers to the full significance of these broad problems, we hope it can stimulate discussion toward their end.

We are wondering whether new concepts, new scopes for the instrument companies, and a new kind of engineer have emerged, namely, the system concept, the system development section of the instrument company, and a system engineer. This will certainly be true if trends in industrial control design exploit the opportunities of feedback control which require, among other factors, the following:

(*a*) A full-scale recognition of the "system" problem, in order to yield a well-balanced and effective engineering solution.

(*b*) Measurement of dynamic properties of physical parts of the system in a way that takes account of the particular environment, age, wear, and tear.

(*c*) Utilization of these measured data with quantitative design information on new systems by the system engineer.

(*d*) Merger of sinusoidal performance criteria with transient performance criteria as a basis for design.

THE DYNAMICS PROBLEM

To design an automatic-control system for a process, one must have an accurate knowledge of the process system dynamics. This embodies not only dynamics of the process reaction itself, but also dynamics of the measuring instruments and control devices which go into the over-all system, and the personnel who function as part of closed-loop operation.

Admittedly, the problem would be one of statics if initially every component in the system could be calibrated or set for the desired steady operating condition and then all units suddenly connected together. This would require that all quantities and all their time derivatives be at the correct instantaneous value when the system is connected. A further requirement would be that the system never deviate from this state. Clearly such a situation cannot exist. The behavior immediately becomes one of dynamics whenever a deviation from one of these established conditions must be made, either as a controlled change or as a spurious disturbance.

The problem is one in dynamics because we are concerned with the rate of transfer of energy. Energy is at all times being redistributed or being expended in a number of places within the system. It is both stored and expended during the injection of raw materials, in the heating of parts of the system, in raising or lowering pressure or temperature, in the process reaction itself. It is basically this rate of energy expenditure, or change of energy storage with time, which quantitatively determines the system stability and the performance quality.

The explicit dynamic characteristics of all instruments and mechanisms involved in the plant are of utmost importance to system behavior. We must know how thermometers, gages, valves, or servomotors behave in response to a signal or a reaction, or how they exchange energy with each other. Thus, to comprehend and to analyze fully the system problem, we must know the dynamics of heat input, of flow, of indicating instruments, amplifiers, motors, and of the process reaction itself. We often speak of chemical processes as slow, fast, or explosive, and by these simple qualitative terms are crudely expressing the kinetics of the chemical reaction which is the key property to process dynamics

To proceed with a quantitative attack on the problem, a compact and usable way of expressing these dynamics over their entire range of behavior is needed. It is not sufficient merely to define behavior in terms of a transient response or a reaction curve for a certain step disturbance. It is not sufficient to say that a controller has proportional, floating, or reset action, to mention a few common control terms. It is incorrect to state arbitrarily whether such properties as self-regulation are desirable in a plant that is to be controlled automatically. Clearly, it is impractical to expect anyone to know enough about every detail of a system—instruments and process—to represent accurately its behavior in terms of differential equations. Anyone forced into this position would inevitably resort to simplification and describe only the most obvious characteristic of a mechanism, thereby ignoring factors that may be equally important from the viewpoint of system dynamics but less conspicuous. In the writing of a differential equation it is very difficult, if not impossible, to take account of environment, wear, change in dynamics with operating level, nonlinearities, and so forth, and end up with an equation that a busy engineer can solve.

A simpler approach to the problem is needed, and we propose resorting to analytical and experimental techniques commonly exploited by the servomechanism people for synthesis of their dynamic systems. Techniques are available for working experimental and analytical data into forms that are readily used by the designer (2). This mathematical and engineering work, although pointed specifically at the servomechanism, has resulted in a clarification of synthesis and analysis techniques for the development of generalized feedback-control systems. It is our opinion that these generalized techniques, with only slight modification, are applicable to the study and

solution of almost any control problem in the chemical, process, steel, aircraft, or any industry.

In the servomechanism field, the synthesis and analysis procedures, which formerly were expressed principally in terms of a transient response, have been supplemented by data that express system phenomena as a frequency response. This does not mean that transients are ignored, they are simply not the only key to the design.[2] As a designer works more and more into a problem along these lines, a deeper appreciation of the effectiveness of his control emerges. His capacity to synthesize control elements increases. Of equal importance is his capacity to examine critically the whole philosophy of closed-loop control. Sometimes this examination yields the disappointing observation that closed-loop control does not exist for the quantity in which he is really interested. This often happens when control is in terms of some reference quantity. For example, we may control a dyeing process by regulating time of immersion, temperature of a vat, or some reference variable. We may also control a refining operation by holding temperature or pressure. In neither case have we really controlled directly for product quality. Fig. 2 is a simple block-diagram representation of these examples. It shows the important physical property, or the quality aspect of the controlled quantity, to be outside the loop. In the dye-control problem, we should have measured color as a spectral distribution over a reasonable band of wave lengths. In the refining operation, we should have measured some chemical property of the fluid or a characteristic such as octane rating, or perhaps the hydrocarbon composition of the fluid, if it were gasoline. One application would have necessitated a spectrophotometer as a measuring means, and the other something like a mass spectrograph. We are here merely trying to point toward explicit control of quality and not mere control of a reference parameter. Each control problem may then need a computer in the loop to interpret correctly the results of these measurements in terms of the kinematics of the chemical reaction, and in turn alter the values of temperature, pressure, or flow of the plant operation as shown by the elementary diagram in Fig. 3. A consideration of these matters now leads us to a discussion of the crucial problem, namely, what do we need in the way of data and how do we get them?

DO WE KNOW ALL NECESSARY DATA?

Although dynamic-response data are becoming more readily available for instruments and control components, they are still far from adequate. Of greater concern, however, is the fact that the specific dynamic-response data of plants and processes in which we are most interested seem to be unavailable.

The pilot operation of a plant or process is often determined by obtaining static physical relations which govern an operating point. The particular physical relations that specify static-energy balances are of only secondary value to the control engineer. He needs to know how these variables change instantaneously within a small zone of deviation from the normal operating point.

A particular problem arises when we consider the physical relationships involving temperature, pressure, and flow. These relationships may indicate the manner in which a product is formed in a process, but they do not relate directly to the quality control or economy of operation of the plant. The dynamics of the physical system may be one study, while the quality dynamics may be a wholly different one. A process to be held at a given operating point may have internal upsets or external environmental changes that fluctuate the physical variables. The average operation over any substantial time may be quite good, but the product being manufactured continuously during these upsets may not have good average quality. Close control of physical variables does not necessarily guarantee minimum contamination or minimum imperfection of product because "degree of perfection" is not the quantity being measured to control the process. Certain forms of automatic control can combat individual external environment upsets in a process; they can be designed to account for internal changes such as aging of catalyst beds but only when the dynamic characteristics of the process are known. The relations between physical variables in petroleum fractionation are a good example of a situation where quantities such as temperature, pressure, and flow in refining of gasoline form one group of dynamic relations and the quality of gasoline in terms of specific hydrocarbon content form a different group of dynamic relations.

The dynamic characteristic data currently available on process behavior and from manufacturers on their instruments and controllers are rarely of the correct kind. Our approach to the synthesis problem calls for dynamic data either as a "time" function or as a "frequency" function which define the process kinetics and the dynamics of instruments and controllers for a period of time or for a range of frequencies, both for a range of operating points.

Frequency functions express the dynamic properties of a system or a component in a compact form. They represent the response of the system or component to a sinusoidal excitation. Assuming a linear system, the response is sinusoidal when the excitation is sinusoidal. Fig. 4 is illustrative of sinusoidal phenomena. Specifically, Fig. 4(*a*) depicts the relative "magnitudes" of two in-phase quantities varying sinusoidally with time. Fig. 4(*b*) shows how a "phase difference" of these two quantities may be shown. Fig. 4(*c*) combines the information of Fig. 4(*a*) and (*b*) into one diagram, showing magnitude and phase relations of two sinusoidal quantities for a particular frequency ω_1. Fig. 4(*d*) shows these relations for a different frequency $2\omega_1$. Fig. 5 is representative of a procedure for expressing the data of Fig. 4 as a frequency characteristic instead of as a wave-form-versus-time graph. The upper curves in Fig. 5 illustrate the manner in which the maximum amplitudes of each sinusoidal quantity vary with frequency, while the lower curves show how the phase angles of these quantities

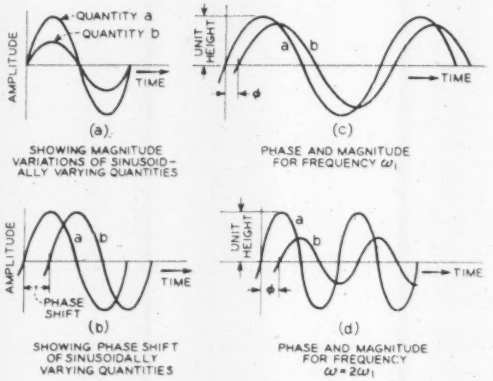


FIG. 4 ILLUSTRATING SINUSOIDAL TIME VARYING RELATIONSHIPS

[2] The advance copy of this paper No. 49-F-11 carried an Appendix which treated certain aspects of frequency-response analysis of feedback systems. The principal purpose of the Appendix was to show that analysis and synthesis of complicated systems follow a well systematized pattern (2, 3, 5).

vary with frequency with respect to an arbitrary reference. The information given in Fig. 5 defines the transfer function which is frequently given the symbol $KG(j\omega)$.[3] The number K defines the properties of the system that are independent of

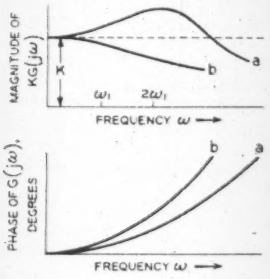


FIG. 5 ILLUSTRATION OF MAGNITUDE AND PHASE-ANGLE PLOTS OF $KG(j\omega)$

frequency, while the function $G(j\omega)$ defines the dynamic properties dependent upon frequency.

Even though a knowledge of dynamic-process relations is essential to permit proper design of any over-all control system, it has already been pointed out that one can probably never write dynamic-reaction equations for complicated processes. An exclusively analytical approach to the problem falls short of representing the process, because of the high degree of simplification required in the mathematics. This calls for action of a different kind to advance dynamic-process studies, namely, the direct measurement of the dynamics, either as a frequency characteristic $KG(j\omega)$, or a time response $R(t)$, on an actual plant or process.

MEASUREMENTS WITHOUT SHUTDOWN

The behavior of a process plant may be measured without requiring shutdown. Since the entire system is dynamical, upper and lower limits are placed on the operating point of all variables such as temperature, pressure, and flow. Measurements could be made at some location convenient from an instrumentation point of view by varying the process level sinusoidally with time (2), within the band defined by these upper and lower operating limits. Alternatively, some convenient quantity may be offset a small amount as a continuous function of time, for example, as a step or a half-sine, and the response recorded as a function of time. From these data the system frequency-response data can be computed (6).

We do not feel that the measurement problem is an easy one. Because it is often a new problem, it may be expensive to perform. The instrumentation required may be special and difficult to procure (4). The choice of location of test points throughout the system, and the instruments used to disturb, detect, and record phenomena must be selected carefully so as not to interfere with the measurement. It may be necessary to make response calibrations of each instrument. The frequency-response or time data procured from these tests on complete plants enable us to prepare loci plots of $KG(j\omega)$ which completely characterize the process variables. Nonlinearities of operation become insignificant when the fluctuations are small about a given operating point. Environment is brought into the investigation simply because the measurements are made on existing, rather than on a simulated, plant. Distance or transportation lags, which frequently give so much trouble in analysis, can be contained completely in the data. Changes in the dynamics caused by such mathematically difficult situations as catalyst-aging can also become an inherent part of the data by repeat measurements made at widely separated time intervals. Of importance to the plant engineer is the fact that the behavior of $KG(j\omega)$ over a range of frequencies about an octave above and an octave below the frequency at which his plant tends to hunt or to cycle gives him adequate theoretical information.

The practical technique for direct measurement may be difficult to master, nevertheless direct measurement as such represents a feasible approach to procurement of dynamic characteristics of systems and instruments too complex for theoretical study. In the final analysis, the manner whereby these data are obtained becomes insignificant because mixtures of measured data and mathematically derived data are used in system synthesis. The procedure could be practiced more often.

The utilization of measured data as outlined in the foregoing gives the system engineer a knowledge of optimum attainable plant operation consistent with a selected degree of stability. It defines the optimum static precision of plant operation in the absence of disturbance. The choice and selection of new control methods for an existing plant are evident. The interpretation of the measured frequency-response or time-response data can focus attention on system synthesis by pointing out the dynamic-response limitations of components of a physical plant or the chemical process, even when ideal instrumentation and control exist.

FUTURE PROBLEMS

Exploitation of the techniques speculated upon herein by the chemical or associated industries for the synthesis of control systems will introduce many new problems. First among these will be the need to review the basic concepts upon which the automatic control is established. New criteria on which to evaluate the adequacy of the practice of omitting the control of product quality from the closed loop and controlling only in terms of some arbitrary quality may then exist.

A new basis for the selection of instruments will certainly be required. It may be necessary to consider more precise measurement of physical variables. It may also become worth while to consider the adaptation of new forms of instruments, such as the color spectrophotometer, the mass spectrograph, supersonic devices, or instruments devised around molecular-structure analysis, refractive index, and so forth. These instruments at the present time are not suitable for direct adaptation. Unless their redesign is accomplished with an eye toward the specific dynamics problem of process control and their incorporation into the system, they may not become useful. This indicates that the development branches of instrument companies may need closer liaison with the process-reaction development section of chemical companies.

The general title, "instrument engineer," is too confining. A new kind of engineer, the "system engineer," is needed for this work. System engineering in contrast with isolated component engineering becomes the crux of the matter. This system engineer will need to draw together individual design specialists concerned with chemical reactions, mechanical structures, catalyst beds, instruments, and the actual installation problems of piping and so forth. He will need to guide these specialists in recognizing that the whole system is an integral design and that the random use of steel by the mechanical designer may very well defeat the purpose of the instrument or the control designer. Instead of being a specialist on a small phase of the problem, he becomes a person well versed

(*Continued on page 136*)

[3] The quantity $KG(j\omega)$ is especially significant in analysis or synthesis studies incidental to plant design. See original appendix or Bibliography (2, 3, 4, 6).

The OUTLOOK *for* CERAMICS *in* GAS TURBINES

By W. H. DUCKWORTH and I. E. CAMPBELL

ASSISTANT SUPERVISORS, BATTELLE MEMORIAL INSTITUTE, COLUMBUS, OHIO

INTRODUCTION

NEW heat-resistant materials are being developed continuously through ceramic research. Part of the research is directed specifically toward gas-turbine applications, and much of the remainder is in some way related to such uses.

Not everyone has the same conception of the ceramic field. For purposes of discussion "ceramics" embrace all that is not clearly organic or metallurgical. To be more specific, it is probably advisable to cite some of the materials which fit under this definition, and which are being considered in the present research. There are of course the old, conventional, silicate-based materials, or those composed of, or bonded internally with glass. Less conventional materials, which do not contain glass, also are included. Many of these glass-free materials have, as primary constituents, one or more of the refractory oxides, carbides, borides, nitrides, and the like. Others are composed essentially of carbon or graphite. In addition, the field includes materials composed of various combinations of metal and inorganic compounds. The metal may be present in these hybrid materials as either a continuous phase or as isolated inclusions.

There are innumerable raw materials and combinations of raw materials from which ceramic articles may be fabricated. Many raw materials and combinations of raw materials remain wholly uninvestigated. They are not being overlooked, but have been neglected because not enough time or effort has yet been spent in research.

HISTORY OF PERTINENT CERAMIC RESEARCH

The pertinent research was initiated during the war. It is part of the effort directed broadly toward the discovery, development, or refinement of materials to meet temperature requirements peculiar to propulsion of high-speed high-performance aircraft and guided missiles. Prior to this interest in ceramic materials, applications for these materials did not involve designs where shape and dimensions were so critical, or conditions of stress and temperature nearly so severe. To illustrate the marked differences in past and present demands for ceramics, the contrast between service conditions for spark-plug insulators, wall tile, refractory brick, or metallurgical crucibles, and those for rotor blades might be considered as representative.

As might be expected from the considerable differences between past and present demands, ceramic materials available when this research was started generally were not adaptable to the new uses. Unfortunately, the adjustments needed to improve their likelihood of success were rarely simple ones. Some mention was made previously of the fact that these conventional ceramic materials are characterized by the presence of a glass phase. It so happens that glass has notably poor resistance to thermal shock and tends to soften and deform under stress at relatively low temperatures. Even if a ceramic material is almost wholly crystalline, containing glass as only a contaminant, the glass phase may interfere with the continuity of the crystal phase and serve as a "lubricant" under stress at high temperature. The glass phase can hardly be tolerated in structural parts for the hot zones of gas turbines.

The elimination of glass from the final product necessitates excluding silicates from the raw materials. Clay, among other raw materials, cannot be used. Ceramists utilize the plastic properties of clay in forming articles. After forming, the clay bonds the nonplastic particles so that the shape has sufficient strength for necessary handling until it is fired. Further, during firing, the clay enters into thermochemical reactions which develop the fired or glass bond. The properties of the final article depend largely upon the nature and extent of these reactions. Clay has a big role in each major step of the fabrication process.

GLASS-FREE REFRACTORY MATERIALS

The development of a ceramic material for a specific use might be divided conveniently into three main phases of research, (1) raw-material selection, (2) forming, and (3) heat-treating.

The initial selection of raw materials is based primarily on melting point, stability, and availability. There are many raw materials and combinations of raw materials which remain unexplored. In glass-free ceramics, where silicates must be excluded as raw materials, the supply still greatly exceeds present research demands. This favorable situation probably will persist for a long time. Investigators are continually uncovering additional refractory compounds of interest, and it is a quite lengthy procedure to develop an optimum body of a selected composition.

Investigations pertinent to gas turbines have been rather thorough on most of the refractory oxides singly, and on many combinations of oxides. There is room for much more research, however, on combinations of oxides. With a few exceptions, the development of bodies from other likely raw materials has been preliminary in nature, or has not been undertaken. The exceptions mainly involve some combinations of oxides and metals, oxides and carbides, and developments stemming from the background on carbide cutting tools. In the latter category, the development and evaluation of mixtures of titanium carbide and cobalt for rotor blades is well advanced. In general, the surface has only been scratched in the detailed development of bodies of refractory carbides, nitrides, borides, silicides, and the like, singly, in combination with each other, or combined with metals.

It is not surprising that the oxides have received more attention than the other raw materials. They are more available or more easily prepared, and of course more stable in the oxidizing atmospheres usually encountered in service.

After selection of the raw materials, the next major problem

Contributed by the Gas Turbine and Power Divisions and presented at the Annual Meeting, New York, N. Y., November 27-December 2, 1949, of The American Society of Mechanical Engineers.

is to form them into some desired shape. Considerable success has been had in research along this line. The raw materials for forming normally consist of fine nonplastic powders. The use of various organic compounds with these powders, as bonding and plasticizing agents, has apparently progressed to a point where they are commensurate with clay for ceramic forming. It is no longer much of a problem to use any of the conventional ceramic-forming techniques of dust pressing, plastic extrusion, or slip casting in the fabrication of shapes of such inorganic and organic mixtures. Further, it is often possible to produce these shapes so as to have sufficient strength for easy machining while in the green unfired state.

Finally, after appropriate curing or drying, the formed shape is subjected to a heat-treatment or sinter. The changes which occur in the internal structure during sintering determine the properties of the product. The mechanism of sintering is not fully understood at present, and the action is influenced greatly by several factors. For these reasons, development is hindered most in this phase of research.

Normally, during the early stages of heat-treatment, any organic materials present are oxidized and removed, or are volatilized with a carbon residue remaining. On further heating, the crystalline particles usually coalesce, and chemical reaction, solution, recrystallization, or grain growth may occur. The nature and extent of the phenomena which occur in the structure do not depend solely on the composition, and the time and temperature of sintering. They are also affected, and often to a great extent, by such factors as impurities and minor additives as well as the major constitutents, the grain size and character of the raw material, the forming method used and degree of compaction during forming, and the atmosphere during sintering. The influence of these many factors makes it necessary to carry out an extensive program in order to arrive at the best internal structure for a selected composition and use. However, more is learned every day about the sintering process. Knowledge is being acquired on how the bond between particles is developed, and on the manner in which the bonding action is influenced by various factors. With this increasing knowledge, the problems in developing ceramic materials for gas turbines are becoming simpler.

EVALUATION OF CERAMIC BODIES AS ROTOR BLADES

In general, some of the appraisals of ceramic materials are empirical, based on service testing, while others are theoretical, based on property determinations. The two approaches of course complement each other, and the sole use of either would be impracticable.

The applicability of ceramic bodies as turbine-blade materials has been described previously by Bobrowsky.[1] In his discussion of the subject he covered evaluations based on both property determinations and service testing, pointing out that several ceramic bodies had higher ratios of tensile strength to density than the better commercial alloys at temperatures in the range of 1500 to 2200 F. Creep rates at 1800 and 1900 F apparently were adequate for oxide bodies, the only ones upon which creep data were available. He warned that oxidation problems and difficulties with wheel cooling may be encountered in the use of ceramic bodies with high thermal conductivities, while lack of sufficient thermal-shock resistance may limit seriously the use of low-conductivity bodies. Normally, the nonoxide raw materials and metal incorporations contribute to high conductivity, while low-conductivity bodies have high oxide contents. In service tests, blades of both an oxide body and of a metal-bonded titanium-carbide body were operated at temperatures above those presently used with alloy blades, but at lower rotor speeds, and under less severe thermal-shock conditions. These service tests revealed certain problems in the use of the ceramic bodies. There were stress concentrations between wheel and blade when the ceramic blades were substituted directly in present metal designs. Severe thermal shock, resulting from failure of the air supply, caused fracture of blades in one instance. Mechanical-shock problems also were encountered.

It is interesting to note that each shortcoming of the ceramic blades in these service tests is traceable to lack of ductility. If a ductile body exists, we are not aware of it. Also, the possibilities of developing such a body seem remote. This same situation apparently exists with new high-temperature alloys. Sweeny,[2] writing about turbine alloys, stated: "The metallurgist can produce stronger materials at a given temperature, or equally strong at a higher temperature, if the mechanical engineer can learn to fabricate and assemble materials with lower ductility. Close co-operation will be required in the years ahead between the metallurgist and the engineer in the development of new and better alloys that can be adapted to gas-turbine designs." These quoted remarks appear equally applicable to ceramists, and, in the interests of promoting the closer co-operation between ceramists and gas-turbine engineers in the future, it might be well to mention some factors which we feel are significant.

ROLE OF GAS-TURBINE ENGINEERS

As an outlook, several ceramic bodies, presently available, might have adequate properties to permit increases in the operating temperature or stress, or both, on present rotor blades. Better bodies can be expected in the future. All of these bodies, however, are nonductile; hence mechanical shock and stress concentrations are expected to present critical problems in their use. Accompanying the brittleness, some of the bodies also have serious thermal-stress limitations. Maximum performance from ceramic bodies as rotor blades therefore depends on design and operational adjustments to counteract this brittleness. These adjustments, for the most part, involve problems in gas-turbine engineering beyond the ken of ceramists.

Further, evaluations based solely on property determinations shed little light on the influence of lack of ductility on service performance. For example, thermal-shock requirements for a given use cannot, at present, be related to the thermal-shock properties of a material. The requirements depend on design as well as time-temperature relationships, and the properties appear to depend on the magnitude of several other physical properties at the time of failure. Some sort of simulated service test therefore is required for adequate appraisals. The need for strictly gas-turbine engineering is apparent here. According to Sweeny,[2] again we find this same problem in metallurgy. Paraphrasing his words, we can say, "...both the ceramist and the engineer have a fundamental challenge of a different sort—that is, to develop a laboratory test for evaluating materials that correlate closely with service experience. Until such a measuring stick becomes available, the full development of better bodies will be impaired."

Becoming somewhat less practical, there is another consideration where close co-operation between ceramists and gas-turbine engineers might be beneficial. Ceramic bodies are inherently stronger in compression than in tension, as well as inherently brittle. The compressive strengths of some of the oxide bodies are of the order of 10 times their tensile strengths. This of

[1] "The Applicability of Ceramics and Ceramals as Turbine-Blade Materials for the Newer Aircraft Power Plants," by A. R. Bobrowsky, Trans. ASME, vol. 71, August, 1949, pp. 621–629.

[2] "Wanted: Better Criteria for Turbine Alloys," by W. D. Sweeny, *Metal Progress*, vol. 55, 1949, p. 315.

course indicates that the best design would have ceramic parts either prestressed in compression, or subjected to compressive loads. Apparently, little has been done along this line. If suitable designs could be evolved, prestressing offers possibilities of reducing thermal and mechanical-shock problems, as failures from such shocks probably are basically tensile in nature. If, on the other hand, the blades are subjected to compressive loads, porous bodies might be used. These bodies would have lower strengths, but better shock resistance than similar dense bodies.

EVALUATION OF CERAMIC BODIES FOR STATOR BLADES AND COMBUSTION CHAMBERS

With lower mechanical requirements, stator blades offer a somewhat more likely future for ceramic bodies than rotor blades. Ceramic stator blades, made from bodies too weak for rotor blades, but with good thermal-shock resistance, might be satisfactory. Even without higher operating temperatures, it is possible that such blades would reduce weight and cost if used to replace metal blades in present designs.

As in the case of rotor blades, physical properties cannot, at present, be related to service requirements in a manner suitable for precise theoretical appraisals. However, as approximations, a few possibilities might be discussed. Bodies which are strong enough to withstand the thermal shock by virtue of being porous, may exist. There is sufficient background on oxides, such as magnesia, alumina, or zirconia, and on zircon for their quick evaluation as primary constituents of such bodies. In view of the considerable progress in ceramic research on protecting graphite bodies against oxidation, these also are possibilities. Certainly they would resist the thermal shock and, perhaps, the corrosion and mechanical stress. Although limited in temperature resistance, fused silica and cordierite bodies should warrant detailed evaluation because of their low thermal expansion resulting in good resistance to thermal shock. They might be satisfactory for present operating temperatures, or slightly above. High-conductivity bodies, such as those of silicon carbide or titanium carbide, also have good shock resistance and may work.

This list of potential stator-blade materials undoubtedly could be extended. It is believed sufficient, however, to show that there are several ceramic approaches to the problem. The economic advantages are also emphasized, as all of the bodies mentioned are prepared from readily available raw materials and have much lower unit weights than the heat-resistant alloys.

Active, but rather limited, consideration is being given ceramic stator blades in simulated-service tests. Unlike the rotor-blade tests, the thermal-shock conditions in these tests are as rigorous as those in present turbines. The early results do not permit definite recommendations, but are considered sufficiently encouraging to predict that improved stator blades can be made of present-day bodies with little or no refining.

Ductility undoubtedly is necessary in the combustion-chamber liners of present designs, thus eliminating direct substitution of ceramic bodies for the sheet metal now used. There are indications that metal-supported ceramic liners will withstand the conditions of service. Also, ceramic bodies might be used to insulate combustion chambers if the need becomes sufficiently acute to justify design changes. Considerable success has been had in so insulating much hotter rocket chambers.

CERAMIC COATINGS

In addition to the work on ceramic bodies, a large portion of the ceramic research pertinent to gas turbines is directed toward developing and evaluating refractory ceramic coatings for metals. Such coatings seem particularly attractive for immediate use. They are not expected to afford outstanding benefits, but they are likely to extend significantly the usefulness of alloys, and few, if any, design changes are anticipated in order to use them. The primary purpose of the coatings, presumably, is to seal the metal surface against corrosive attack, and secondarily to provide thermal insulation. Not much can be expected from them as insulators as they must be thin in order to be tough and adherent.

Most of the work on coatings has been confined to the enamel type. These consist essentially of a thin layer of glass and, as such, are subject to yielding under stress at relatively low temperatures. However, we are not so concerned with this weakness in coatings as in bodies because the base metal, not the coating, bears the stress. Spall-resistant coatings have been developed to "fit" the low-carbon and low-alloy steels, and the significant heat-resistant alloys, with the possible exception of high-molybdenum or tungsten alloys. The refractoriness of some of these coatings is such as to afford protection for long periods at temperatures up to at least 1800 F. In laboratory tests, coated specimens have been unaffected under conditions of time, temperature, and atmosphere which caused complete deterioration of uncoated specimens. • In service tests, instances are reported where the enamel-type coatings have increased the life of rotor blades and combustion-chamber liners appreciably. The worth of these coatings, however, has not been established definitely through extensive service testing. It is not known, for example, whether they will permit increases in operating temperatures, or which of several available coatings are better. The reasons for the reputed beneficial effects are not clearly understood. If they were, better coatings for the specific uses probably could be developed. Here, again, close co-operation between ceramists and gas-turbine engineers, along with metallurgists, might pay off.

Another coating development has produced spall and oxidation-resistant coatings of metal-ceramic combinations. Some of these appear to be more heat-resistant than the enamel-type coatings, and more techniques have been developed for their application. Little success has been had in maturing the enamel coatings by means other than furnace firing, while the metal-bonded coatings can be matured with a torch, or even flame-sprayed. The relative merits of these coatings as compared to enamel coatings have not been established. The characteristics of the two types are rather different, and each may have uses in gas turbines for which it is particularly suited.

As temperature requirements for materials of construction are pushed slowly but continuously upward by design engineers, attention is being given to new techniques for the application of refractory coatings not readily applied by conventional methods. The most generally useful methods developed to date for the formation of refractory coatings involve the so-called vapor-deposition processes in which the coating is formed by chemical reaction at the heated surface of the base material. Commercial application of vapor-deposition processes has, as yet, been limited to materials for moderate-temperature service, e.g., chromized steels, siliconized iron, and so forth, but current research has shown promising results in several applications of interest to gas-turbine engineers.

In vapor-deposition processes, volatile compounds containing the coating elements are passed over the work, which is heated to a temperature at which the components of the plating atmosphere react to form the desired coating. The base, itself, may, and frequently does, enter into the plating reaction, but this is not necessarily the case. Specific examples of processes for the formation of refractory coatings include the deposition

(Continued on page 144)

HOUSINGS *and* SPINDLES *for* ANTIFRICTION BEARINGS

By H. L. BLOOD

ENGINEER, THE HEALD MACHINE COMPANY, WORCESTER, MASS.

INTRODUCTION

THE fine literature supplied by makers of ball and roller bearings contains a wealth of information, yet the machine builder must often search for more. It is the aim of this paper to shed some light on the less well-known but important points to be considered in the application of antifriction bearings.

For example, if deflection and vibration are important considerations the spring rates or stress-strain curves of the bearings should be known, in order to decide on the best location for the bearings. The same information will be helpful if critical speeds are to be studied. To determine the proper fits and allowable tolerances for housings and spindles it is necessary to estimate how much the bearings will expand under axial load, as well as their thermal expansion relative to the housing under operating conditions.

DEFLECTION OF SPINDLE AND BEARINGS

Where deflection and vibration need not be considered, sufficient information will be found in catalogs for selecting bearings of proper capacity. The radial and axial load ratings are based upon the service life which may be expected for a large percentage of the bearings. Generous factors of safety should be applied for a longer life and for a smaller percentage of failures, and to allow for variations in fits as well as for errors in alignment.

Where deflection is important, the radial and axial spring rates of the bearings under expected preloads and external loads should be obtained from the makers. It is to be hoped that such information will be made more readily available. Deflection in the bearings depends to a large extent on the shaft and housing fits, as well as on the radial rigidity of the housing and of the spindle, if it is tubular. Therefore data on bearing deflection should be given in such a way that the spring rate corresponding with the mounting may be selected.

When the spring rates are known, the approximate deflections of spindle and bearings may be calculated. Since spindles usually have steps of different diameters, it has been customary for some bearing makers to make these calculations for their customers. However, formulas are available[1] which make it easy for users to compute spindle deflections for themselves and to compare the effects of using different sizes and types of bearings and of changing their location. The best location for the bearings will depend largely upon their spring rates. For example, in the case of a cantilever type of spindle with two bearings, the stiffer the bearings the closer together they should be for the minimum combined deflection at the load point. In fact, if the bearings could be infinitely rigid, the stiffest spindle would be one having no length between bearings.

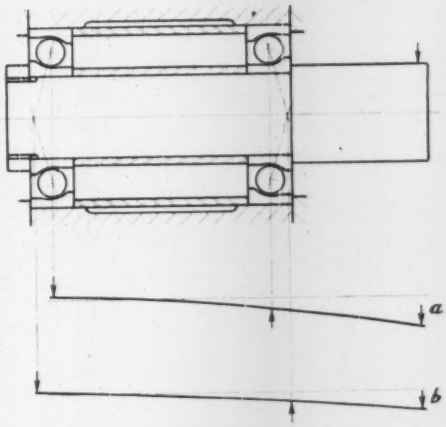


FIG. 1 DEFLECTION OF SHAFT AND BEARINGS; CANTILEVER LOADING

(*a*, Calculated deflection assuming that shaft is supported at center of bearings. *b*, Deflection assuming shaft is supported at apexes of lines of contact in bearings. This assumption agrees closely with deflection tests on shafts of typical proportions.)

In order to reduce deflection between bearings, they are often mounted somewhat closer together than they would be if the only criterion were deflection at the load point. Spindle stiffness makes for smooth running and long life, by reducing unbalance and by maintaining better alignment of the bearings.

When calculating the deflection of a spindle carried by angular-contact bearings, the angle of contact is sometimes neglected, and the spindle is considered as supported at the center of the bearings, as at *a*, Fig. 1. This assumption is incorrect, because it yields the same calculated deflection whether the bearings are back to back or face to face. Obviously, if two bearings are mounted face to face and located so that the areas of contact between balls and outer races lie approximately in a sphere, the bearings will be practically self-aligning. But if the bearings were turned back to back they would support the spindle much more rigidly. An assumption which agrees closely with the results of actual deflection tests on spindles of typical proportion is shown at *b*, Fig. 1. Here the spindle is considered as supported at the apexes of cones passing through the points of contact between balls and races. In other words, a bearing with a 15-deg angle of contact may be assumed to support the spindle at the intersection of lines passing through the center of each ball at an angle of 15 deg from the face of the bearing.

[1] "Deflection and Critical Speeds of Stepped Shafts," by H. L. Blood, *Machine Design*, vol. 18, June, 1946, pp. 155–157.

Contributed by the Machine Design Division and presented at the Annual Meeting, New York, N. Y., November 27–December 2, 1949, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

SHAFT TOLERANCES FOR ROLLER BEARINGS

A slight interference fit has been found necessary for tapered roller bearings on rotating shafts, to prevent the inner race from creeping on the shaft and wearing the shoulder which backs the inner race. Wear of this shoulder would of course change the adjustment of the bearing.

Shafts for cylindrical roller bearings also are made a press fit on the inner races. For example, one manufacturer recommends in his catalog an interference of 0.0008 to 0.0022 in. for a 216 size. Some users prefer, by holding the shaft to close limits, to make the interference 0.0014 to 0.0022 in. for better control of the internal clearance in the bearing.

The internal clearance of cylindrical roller bearings used in gas turbines must be still more accurately controlled. Here the fits are held to extremely close limits by selective assembly.

Another type of cylindrical roller bearing has a tapered bore which is adjusted along a tapered spindle to expand the inner race and preload the bearing.

SPINDLE TOLERANCES FOR BALL BEARINGS

In many ball-bearing applications, clamping nuts are omitted and a tight fit is depended on to secure the inner race to the shaft. There is a growing tendency toward this practice in such applications as electric motors. Ball bearings, however, are not pressed on shafts as tightly as roller bearings.

Handbook and catalog tables of recommended fits should be consulted. The tables should correspond with the ABEC grade, that is, the tolerances of the bearings used. The tables should also show the type of service to which they apply so that allowance can be made for such factors as higher speeds, heavy or eccentric loads, or high precision. Such tables are often based upon practical tolerances for bearings and spindles, which add up to variations in fits which would be too wide for precision work.

The fit of a ball bearing on a spindle should of course be close enough so the spindle will run true and not be damaged by creeping of the inner race. On the other hand, the fit must not be so tight as to cause rough operation where this is important. Tolerance can be widened in the direction of tighter fits if the inner race is ground with uniform wall thickness, because mounting on a round spindle then tends to correct the ball track.

Selective assembly is used to increase uniformity of fits in precision work. Experiments to determine the loosest permissible fit may be justified, particularly if it is found that lapping spindles to fit each bearing can be avoided. Such individual fitting cannot be practiced in the shop without admitting harmful dust into the unwrapped bearings.

Where it is impossible to avoid individual fitting, it will be helpful if bearings can be sealed by the manufacturer in such a way that they can be tried on the spindle without removing the seal.

Ball bearings for high-precision work usually are marked to show the eccentricity of each race and the high point, so that races can be assembled with their high points in line.

The order of magnitude of permissible face runout for spindle shoulders may be judged from the face runout tolerance of the bearings, as recommended by the maker for the particular type of application.

The face runout of bearings, as well as the bending of the spindle due to clamping, of course will depend upon how accurately the spindle shoulders which locate the bearings are shaved, ground, or lapped, and on the squareness of the faces of nuts, sleeves, and slingers between which bearings are clamped. In precision work it is good practice to grind the threads and faces of nuts true with each other and to grind the threads on the spindle. A precision spindle should be checked with an indicator after all parts have been assembled on the spindle and clamped. Any serious bending should be corrected by lapping the faces of the nuts.

A resilient washer is sometimes placed between a clamp nut and a bearing to reduce spindle distortion.

HOUSING TOLERANCES FOR ROLLER BEARINGS

In housings for cylindrical roller bearings the most common fit is a "tap fit," for example, 0.001 loose to 0.0004 in. tight. Such a fit avoids excessive reduction of the internal clearance which would occur if both housing and shaft had press fits. With this type of bearing it is not necessary for the outer race to slide in the housing to permit axial expansion of the spindle.

For taper roller bearings with stationary outer races, manufacturers recommend that the housings be made as close as possible to a metal-to-metal fit. If the outers revolve it is important that they be mounted with an interference fit.

With either metal-to-metal or interference fits in a rigid housing, thermal expansion can build up tremendous pressure on the bearings. This has limited the speeds at which taper roller bearings can be run. Manufacturers of this type of bearing have been working for years to develop a mounting which would permit radial expansion without introducing looseness, and have arrived at the principle shown in Fig. 2. The cup of the rear bearing is carried in a sleeve, one end of which expands with the bearing and tends to fill the slight clearance between the sleeve and the housing bore. A clearance of from 0.001 to 0.004 in. on the diameter, depending on the size

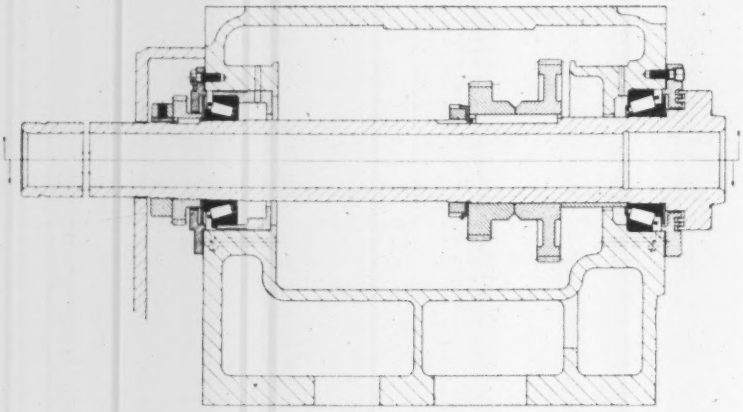


FIG. 2 TYPICAL MOUNTING TO PERMIT THERMAL EXPANSION OF BEARINGS

(Alternate designs are shown above and below center.)

of the bearing and the requirements, is obtained by finishing a land on the sleeve after the cup has been pressed into the sleeve. The other end of the sleeve is a relatively tight fit in the housing.

This general design has made possible much higher speeds than could be obtained with a rigid mounting, and the principle has been used successfully in several different machines. The design shown is for a particular machine and should be modified to suit other applications.

HOUSING TOLERANCES FOR BALL BEARINGS

It is generally agreed that the fitting of housing bores to suit individual bearings should be avoided. Unwrapping a bearing for fitting before final assembly is almost certain to admit shop dust, a danger which cannot be stressed too strongly. Not only is such fitting expensive, but it has been found that the accuracy of a precision-bored or ground hole is very apt to be destroyed by lapping, especially where it is necessary to work close to a shoulder. The difficulties lie in expanding the lap without producing a taper, and in guiding the lap so that alignment will be preserved. A housing with a straight-through bore and no shoulders, Fig. 1, is more easily lapped.

It seems to be human nature to want to fit housings to bearings in precision work. If a particular fit has been found satisfactory, such as a "firm push fit," a "light thumb push," or a fit which will allow the bearing to slide by its own weight, it is natural to attempt to reproduce this fit in all assemblies. Yet the difference between these fits is so small as to be difficult to measure.

If housings are fitted to bearings, this is done as a rule when the bearings are cold and unloaded. The fits will be entirely different when preload has been applied and the bearings are at running temperature.

Axial load or preload applied to an angular-contact bearing increases the angle of contact, both by compressing the balls and races and by expanding the outer race if it is not constrained. This consideration alone would indicate that the race should fit the housing snugly.

On the other hand, bearings are a source of heat, while a typical housing acts as a radiator and reaches a temperature intermediate between that of the bearings and the surrounding air. The bearings therefore expand relative to the housing by an amount which may be large compared with the radial clearance in a ball bearing. For example, in a Size 216 angular-contact bearing, an internal clearance of 0.001 in. on the diameter is not unusual. If the thermal expansion of the housing is assumed to be two thirds that of the bearing, a rise of 40 F would expand the bearing approximately 0.0004 in. relative to the housing. In the case of a low-angle or radial bearing, the effects of thermal expansion are still more serious because of the smaller internal clearance.

If the clearance around a bearing is not large enough to allow the outer race to expand, heating will reduce the angle of contact, that is, the wedging effect produced by axial load may be increased manyfold. This does not mean that the housing bore necessarily should be large enough to permit full expansion of a bearing which is not required to slide in the housing. It does mean that the difference between the operating temperatures of the bearing and housing should be considered in setting tolerances.

In the majority of ball-bearing applications, it is important for at least one of the bearings to slide in the housing to accommodate axial expansion and contraction. A bearing cannot slide unless the clearance around it is nearly equal to the combined expansion from axial load and from temperature. Fortunately, it is often possible to check whether or not a fit is too tight by running a unit until operating temperature is reached, stopping it, and measuring the external load necessary to move the spindle lengthwise. In some designs it is necessary to loosen an end cap to make this check.

When one considers the magnitude of thermal expansion, which does not prevent successful operation of ball bearings in general, a few "tenths" variation in initial clearance seems less important. Examined from this point of view, it may be found that entirely satisfactory fits can be obtained with practical tolerances by precision-boring or grinding the housing.

If the housing bore is measured with a two-point dial gage, the readings are apt to be misleading. Measurements with two small gage points may indicate that the housing bore is larger than the bearing, and round, yet the bearing may not enter. A three-point air gage, or electric gage with low contact pressure and large points, is preferred for precision work.

Several readings should be taken to check roundness of the bore, and the method of clamping the housing for boring should be improved if necessary to prevent distortion.

In the case of aluminum housings it is customary to make the fits relatively tight so they will not be too loose at running temperature. Warming the housings will facilitate assembly and removal of bearings.

Many housings have shoulders against which outer races are clamped. Squareness of the shoulder with the bore of the housing, and flatness of the surface, are important. It is good practice to check shoulders with an arbor having a square face and located from two bearing seats.

Here again the tolerance should be consistent with the face runout of the outer race, as recommended by the maker. Methods of manufacturing bearings are being improved, with special attention to the elimination of face runout and waves or wobble in the ball tracks. These irregularities cause the balls to contact the side of the track at different diameters, changing their speed, which increases the wear between balls and the retainer.

Both ball and roller bearings are available with races ground to a uniform thickness, so that contact with the bore of the housing tends to correct rather than distort the races.

These improvements in bearings should be matched by the accuracy of the surfaces which support them.

PRELOADING

Ball bearings are obtainable in matched pairs which, when clamped together, have a preload. Light, medium, and heavy preloads are supplied for different types of service. However, no uniformity exists between the practices of different makers. Standardization is badly needed for the benefit of the user.

Preloading of ball and roller bearings is also accomplished by adjustment. Information is needed from the bearing maker by which the proper preload can be determined, as by measuring the friction torque of a pair of bearings or by measuring the amount of adjustment.

Preloads are affected greatly by the temperature of the bearings and related parts. Variations in load are sometimes reduced by sleeves of high-expansion or low-expansion material between bearings.

Preloading by springs is often highly satisfactory. Belleville springs are useful where space is insufficient for long springs.

ACKNOWLEDGMENTS

The collaboration of the following is gratefully acknowledged: Mr. Frank U. Naughton, Hyatt Bearings Division, General Motors Corporation; and Mr. S. M. Weckstein, Timken Roller Bearing Company.

Selecting ANTIFRICTION BEARINGS *for* MACHINE TOOLS

By JOHN H. BANINGER[1]

NEW DEPARTURE DIVISION, GENERAL MOTORS CORPORATION, BRISTOL, CONN.

GENERAL INFORMATION

TODAY machine tools are being built for higher speeds and they are required to work to closer tolerances than ever before. In order properly to comply with these increased speeds and conserve the life of the cutting tools, the edges of which may be prematurely broken down by vibration or chatter, it has become necessary to incorporate in machine tools a higher degree of precision and rigidity. It is clear that this precision and rigidity must be directed most particularly to those parts of the machine which either hold or rotate the work or hold or rotate the cutting tools, as the case may be. Further, the revolving parts must be so mounted that the highest working speeds can be maintained without excessive heating or affecting accuracy in the bearings by which they are supported. Finally, the original precision and rigidity must be maintained throughout the useful life of the machine.

It is common knowledge that the limits of plain sleeve bearings do not cover these requirements in every respect, and this inevitably leads to the increasing use of antifriction bearings, not only in the drive and feed mechanisms, and the like, but also on main spindles.

Since the duty demanded of bearings in this kind of service is so very exacting, the problem naturally has arisen as to what type of antifriction bearing may be used to fulfill certain requirements most completely.

The three principal types of antifriction bearings are ball bearings (radial and angular-contact types), straight roller bearings, and tapered roller bearings. Just what advantages may be attributed to these types of bearings depends mostly on the speeds at which they operate and the loads they have to carry without generating too much heat. It may be said that, for slow speed and heavy radial loads, the roller types are more generally used, while for very high speeds and utmost accuracy, or for heavy thrust loads ball bearings are customarily preferred.

All three types must be truly antifriction both in principle and in operation, for upon this depends to a large degree the life, accuracy, and ability to function for long periods under normal operating conditions without heating up.

They must be highly accurate, for this quality is the base upon which the running truth must be built, especially for supporting main spindles.

All must resist dual loads in any combination with minimum variation in efficiency and deflection, for in a machine-tool spindle the radial and thrust components may vary in relation to each other over a wide range of load combinations.

Abundant load capacity for all contingencies is a necessity, for it must be possible to work the machine to its full rated capacity without jeopardizing the efficiency or life of the bearings.

[1] Assistant Chief Engineer.

Contributed by the Machine Design Division and presented at the Annual Meeting, New York, N. Y., November 27–December 2, 1949, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Finally, the bearings must provide permanently a high degree of rigidity under all loads and speeds, for this quality is essential not only to the accuracy and finish of the work produced but enables full life to be obtained from the cutting tools in the machine itself. For any kind of heavy-duty machine tool, using more or less the same construction for the main spindle, this part, if mounted on ball bearings, must be somewhat heavier than if supported by roller bearings to obtain the same rigidity and consequent accuracy in the work produced. The reason for this statement is obvious—ball bearings have a curved, elliptical contact, while most roller bearings have a straight-line or rectangular contact. For the roller-bearing mounting, however, under spindle deflection the radial load is not evenly distributed over the full length of the rollers but is transferred to a certain extent toward one edge of them with the result of concentrating the load on a reduced area. This not only increases the pressure per unit area but also generates more friction and heat.

INSTALLATION

Three bearings for supporting a spindle or shaft should be avoided if at all possible mainly because of difficulty in maintaining alignment resulting from distortion of a housing not having uniform cross section; because of localized heating; or when fastening the housing to the base. Exception can be taken when using an extremely long-quill construction.

Bearings with a large number of balls have less radial deflection under the same load than bearings with the same outside diameter but having fewer balls of larger size.

For spindle mountings, bearings with small cross section should be given preference to those having larger balls, and thus larger cross section, thereby permitting the use of a stiffer spindle.

For a high-speed shaft on which a heavy thrust load is imposed, the bearing selected for resisting the thrust, if at all possible, should be mounted at the end of the shaft, thus permitting selection of a size of the heavy series having a bore smaller than the shaft without sacrificing shaft stiffness and thereby keeping the manufacturing cost low.

BEARINGS FOR HEAVY-DUTY SPINDLES

For rigid and accurate spindle mountings, the duplex type of bearing is most widely used because it is easier to produce two single bearings accurately than a double-row bearing. A duplex bearing has other advantages over a double-row bearing which leads to its preference. It can be preloaded much more heavily because the preload is applied after the pair or set is mounted on the spindle and installed in its housing. The preloading of a double-row bearing is limited simply because the balls can only be inserted by expanding and deforming the bearing outer ring. Obviously, it takes much more care and effort to assemble such a bearing without encountering the danger of injuring it while inserting the last few balls of the second row. Also, if the amount of interference of balls and races cannot be

absorbed through deformation of these parts, the bearing outer ring will be forced out of shape and will scallop around each ball, and the bearing outside diameter will exceed its maximum-limit dimension. The housing bore also must be increased so that the bearing will enter it without the danger of being damaged.

When applying preload, the outer rings of a duplex bearing will expand a small amount and take up the clearance provided for easy assembly in the housing. Thus a metal-to-metal contact between the bearing outside diameter and housing is obtained. This is absolutely necessary not only to secure the required spindle rigidity but also to maintain the shape of the bearing outer rings and distribute the pressure more uniformly onto the balls, thus maintaining the rated load capacity.

Duplex bearings can be obtained to five different specifications with different contact angles. The preload is specified by the customer to meet his operating conditions in the simplest and most suitable manner. Since these bearings are matched in pairs or sets not only for preload but also for uniform bore and outside diameter, they should be kept together and installed that way. For precision units it also is recommended that customers install the bearings with the high spot of ring eccentricity and runout in alignment, thereby keeping bearing temperature and vibration to a minimum. The high spot of eccentricity usually is etched on the ring face with a burnished mark about $^1/_{16}$ in. diam, and a check mark is employed to indicate face runout.

For certain installations, subjected to severe intermittent thrust and radial pressure from their cutting tools, the spindle nose can be supported advantageously by using a pair of duplex bearings, DB type, having different contact angles to obtain more uniform spindle rigidity. Since the axial pressure from the cutting tool or wheel is usually in the direction toward the headstock, the spindle-nose front bearing preferably should have a higher contact angle than its mate and thus the outside pressure required to relieve the back bearing of some of its preload will be considerably higher. Furthermore, due to the two different contact angles, ball velocities of the bearings vary. This also will assist in bridging over uneven bearing deflection when load passes directly over the balls and between them.

Duplex bearings of the DT type also can be mounted DF or DB. If installed DB fashion the preload is applied to the inner rings but for DF type the preload is applied through the bearing outer rings. Today most of the ball-bearing manufacturers produce duplex bearings to DT type which, from the stock room as well as service standpoint, makes this type not only very flexible but also attractive as the number of parts is held to a minimum.

The adoption of a flange-type bearing for spindle-nose support is being favored more frequently as it permits the use of a straight-through hole in the headstock. Such a hole is much easier to machine and inspect, and can be obtained at considerably lower cost, which compensates for the higher cost of such a bearing.

It is common practice to support the main spindle for a heavy-duty machine tool with a pair of duplex bearings at the front and a slightly preloaded double-row bearing at the rear end. The outer ring of the latter bearing, preferably, should be mounted in a sleeve with a light interference fit to give the bearing the required support, while the sleeve itself should be installed in the housing with a sliding fit to prevent imposing a preload between the two spindle bearings and placing additional strains on the spindle. This sleeve should be interlocked radially with the housing to prevent creeping or revolving, thus eliminating wear between the two surfaces and avoiding any curtailment of bearing life.

An alternative design for spindle rear-end support, using a straight roller bearing, also has proved very satisfactory because the bearing outer ring can be installed with a light press fit directly in the housing, and its inner ring mounted with a heavy interference fit on the spindle to take up the bearing internal looseness and give the spindle rigid radial support. In the event that the axial expansion of spindle and headstock casting varies, then no thrust load can be imposed on the bearings, nor any undue strains transferred upon the spindle as the straight rollers permit independent axial movement of inner and outer rings without affecting the performance of the bearing or the machine. To take up the radial looseness of such a bearing during installation without damaging the raceways, a bearing with a tapered bore would solve the problem very well.

Past experience has taught the machine-tool manufacturers to use antifriction bearings of standard design and over-all dimensions so they can be obtained from more than one source.

BEARINGS FOR LIGHT-DUTY SPINDLES TO OPERATE AT MODERATE SPEEDS

Supporting such spindles on only two bearings, preferably of the "extra light series," is recommended. This will permit using a larger stiffer spindle. A flanged-type angular-contact bearing at the front end, opposed to one of the same size at the rear end of the spindle but without a flange, using spacers for preloading and installed in a headstock housing having a straight-through bore, has been adopted quite extensively because of satisfactory performance. It also can be built at rather low cost. From the service standpoint such a construction is attractive, as all the parts are easily accessible since the drive is attached at the spindle rear end.

BEARINGS FOR HIGH-SPEED SPINDLES

Ball bearings have proved to be the most satisfactory type, mainly because they are not as sensitive as other types of bearings to the application of the essential preloads. Furthermore, ball bearings operating under such conditions rotate more freely and therefore generate less heat, and the method of their lubrication is less troublesome.

It is obvious that the bearings, as well as the parts required for their mounting, must be held to very close tolerances. Nevertheless, provision should be made to maintain uniform preload should the spindle and housing expand unevenly due to bearing heating up. This can best be solved by using spring pressure for preload.

Since the life of high-speed bearings is limited, depending upon uniform preload at all times, perfect alignment, and proper lubrication, it is highly recommended that the quill type of construction be used which, from a replacement or service standpoint, permits very short interruption of machine operation, and thus is very economical.

BEARINGS FOR VERY HIGH-SPEED SPINDLES

For the past few years considerable study and experimentation have been devoted to spindles operating successfully at very high speeds. Since the centrifugal force of the balls must also be taken into consideration for bearing-load calculation, the required bearing size is determined by the bearing outer ring ball track, while the bearing inner ring ball track is relieved of some of its load. Obviously, all the parts for such spindles must be made as close as possible to zero tolerances, especially the revolving parts. Therefore, both from the engineering as well as manufacturing standpoint it is often advisable to dispense with the bearing inner rings and grind the inner ball tracks directly onto the spindle. The high-frequency motor has solved the drive for such high-speed

spindles in a most satisfactory way as the spindle itself can be built up as the motor armature, and its length can be kept rather short. By finishing the outside diameter of the spindle, including ball tracks and armature between centers, it is possible to obtain an absolutely concentric and dynamically balanced spindle. The bearing outer rings should preferably be of the deep-groove type, and in order to use a one-piece, phenolic, ball separator, and still be able to assemble the two bearings, the snap shoulder should be on the outside of the spindle ball tracks and not in the bearing outer rings. The two bearings, must be installed DF type and be spring preloaded, applying the pressure against the bearing outer ring.

The reason for recommending deep ball tracks in outer rings is to take care of slight axial movement of the spindle when centrifugal force of the balls forces them to leave the predetermined angle of contact created by the spring pressure and move closer toward the bottom of the outer ball track. Past experience has proved that if the bearing outer rings do not respond promptly to the pressure created by the centrifugal force of the balls, the balls will contact the snap shoulder if machined in the outer ring, resulting in bearing failure.

DESIGN SUGGESTIONS

Feed Screws. For positioning feed screws usually revolving very slowly but which must be held not only very rigidly but also accurately, a combination of a ball-thrust bearing and an annular bearing has proved most satisfactory.

Drive-Gearboxes and Feed Mechanisms. To obtain quiet, smoothly operating gearboxes, the mounting of rather long shafts on a double-row bearing on one side and a single-row annular bearing on the opposite side has solved numerous problems in a most satisfactory way, i.e., a double-row bearing holds the shaft very rigid both radially and longitudinally. No bearing end-play adjustment is required, and thus no additional strains are imposed on the gear case and shaft. Also, such a construction is foolproof.

Snap-Ring Bearings. The use of snap-ring bearings simplifies the assembly of shafts and also reduces the machining cost of the housing. It likewise permits straight-through boring.

Shielded and Sealed Bearings. From years of experience with shielded and sealed bearings installed in all kinds of instruments, machinery, and the like, enough information has been obtained to determine fairly accurately their useful life. Based upon the success with such grease-lubricated bearings, their adoption is increasing rapidly because no provision is necessary to lubricate them, and they are protected adequately from contamination by foreign matter not only during their installation period but also in actual service, as particles from gear wear, and so forth, are more or less banned from entry in the bearings.

Bearings for Pulleys. Loose pulleys, clutch pulleys, belt-tightener pulleys, intermediate gears, change gears, etc., can be successfully and economically mounted on one double-row bearing of the preloaded type.

Bearings for Rollers. The adoption of ball bearings as cam or guide rollers is recommended only for greatly reduced bearing ratings. Furthermore, if shielded or sealed-type bearings are used for such service, their load should be reduced still further, thereby preventing shields or seals from snapping out of the outer ring groove in which they are held. However, in emergency cases their outer rings must be reinforced considerably to sustain successfully their rated load capacity, but such a bearing becomes a special and, should from a service standpoint, be condemned as it can be obtained from only one source at a prohibitive price.

Antifriction Bearing Slides. The introduction of antifriction-bearing slides for longitudinal tables, carriages, and cross-slides has been received with open arms since tests conducted so far have fulfilled all expectations. However, in order to obtain rigid and accurate support by the use of such slides, whether horizontally or vertically, the balls must be inserted with a predetermined interference so that each ball will be subjected to a uniform preload, regardless of the continuously moving weight they, in addition, have to carry.

Instrument Engineering

(*Continued from page 127*)

on the entire system problem. We may need to revise the pattern of organization of engineering firms to meet the needs of these system problems. Often a line organization with a single head responsible for the scientific aspects of the work must replace a staff organization in order that new designs can be carried through with full recognition of the system problem. Autonomy, often demanded by the specific professional groups that usually participate in such endeavors, may place emphasis on the wrong area if such autonomy is granted.

A review of the practice of concentrating operating and controlling personnel in control rooms where telemetering and inventory recording apparatus are also concentrated needs re-examination in the light of the defects that the dynamics of such telemetering apparatus place in the way of automatic control. Superposed telemetering and inventory instrumentation is one thing, whereas intermingled telemetering for subsequent control may very well jeopardize the control of the process itself.

The attitude of the industries toward plant start-up may be revised. Instances are known where operators are reluctant even manually to start up plants. Many chemical plants were so designed that it is now impractical to start them up and stop them under automatic control. It is only when the approximately normal operation is attained with manual control that many plants are given over to fully automatic operation. These practices often represent an unsatisfactory way of operating. They do not place high responsibility on the control system in whose design the functions of instruments, computers, and human monitors were not well co-ordinated. Achievements in other areas of automatic control seem to indicate that a programmed start-run and shutdown seem desirable and realizable for many industrial processes.

It is not expected that the philosophy of this paper can be adopted in its entirety in any short period. Both technical and human problems are involved. They may take a decade or more to resolve.

BIBLIOGRAPHY

1 "The Functions and Responsibilities of a Plant Instrument Department," by J. G. Kerley, Bulletin, Agricultural and Mechanical College of Texas, fifth series, vol. 3, no. 2, pp. 5–11, February 1, 1947.

2 "Principles of Servomechanisms," by G. S. Brown and D. P. Campbell, John Wiley & Sons, Inc., New York, N. Y., 1948.

3 "Linear Servo Theory," by R. E. Graham, *Bell System Technical Journal*, vol. 15, October, 1946, pp. 616–651.

4 "Frequency-Response Measurements of a Hydraulic Power Unit," by M. R. Hannah, Trans. ASME, vol. 70, 1948, pp. 525–534; discussion, pp. 535–539.

5 "The Dynamics of Automatic Controls," by R. C. Oldenbourg and H. Sartorius, ASME Edition, vol. 70, 1948, 276 pp.

6 "Graphical Determination of Transfer Function Loci for Servomechanism Components and Systems," by C. H. Thomas and E. C. Easton, Trans. AIEE, vol. 68, 1949, pp. 307–314.

Characteristics of GREASES *as Related to* ANTIFRICTION BEARING APPLICATIONS

By E. S. CARMICHAEL and R. C. ROBINSON

SOCONY-VACUUM LABORATORIES, SOCONY-VACUUM OIL COMPANY, INC., NEW YORK, N. Y.

LUBRICATING greases have been defined as dispersions of soaps in mineral oils. Today this definition is incomplete, because it fails to differentiate greases from products such as detergent oils, which also contain soaps or soaplike materials. It is therefore more accurate to define a grease as a soap-thickened oil, which may or may not contain additive materials, such as oxidation inhibitors, rust-preventive agents, and the like, to confer certain desired characteristics thereto. This wording recognizes the fact that the soaps employed in lubricating greases are of the type and concentration which add appreciably to the body of the lubricating oils, whereas in detergent oils the soaps are used for a decidedly different purpose and produce no marked thickening effect.

Lubricating films on bearings packed with grease are composed essentially of soaps, mineral oils, and additives, if present. While it is true that the primary purpose of the soap is to enable the lubricant to "stay put," it is also true that the soap may play an important role in affecting favorably or unfavorably other characteristics, such as load-carrying ability, water resistance, and so forth. This is the basis for the statement frequently made that the viscosity of the oil from which the grease is prepared is only one of many factors to be considered in recommending a grease for a given application.

Before undertaking a brief discussion of some of the characteristics of greases that should be considered in antifriction-bearing applications, it should be pointed out that the performance of a grease is often dependent upon bearing design and the amount of grease that is introduced into the bearing. Some bearings, for example, are constructed without seals. When seals are used, seal clearances may be found to vary over relatively wide ranges. Furthermore, when grease fittings are employed, provision may or may not be made for relief plugs through which used lubricant or excess product may be removed when new grease is introduced. Obviously, a satisfactory seal on an antifriction bearing will aid in minimizing grease leakage and contamination, and a properly placed fitting and relief plug, preferably on the upper and opposite bottom sides, respectively, will facilitate the flushing of used lubricant from the bearing.

It is to be noted that the use of a pressure gun for grease application is not recommended for antifriction bearings in which a drain or relief plug has not been provided in addition to the pressure fitting. In such a case the use of a pressure gun may result in overgreasing or damage to bearing seals. However, such bearings can often be adapted for pressure-gun application by drilling and tapping a drain opening of suitable size. Ordinarily the drain should be located at the bottom of the housing, and as previously indicated, preferably on the side of the bearing opposite the pressure fitting.

The importance of packing antifriction bearings properly cannot be overemphasized, since underlubrication and overlubrication are harmful. Underlubrication may result in little or no grease reaching the ball or roller track. Excess grease in the path of rotating parts will offer high resistance to motion, and overheating and high internal pressure may result. Under these conditions, excessive leakage at bearing seals also may occur, and the effective life of the grease charge may be shortened considerably because of the increased rate of oxidation which occurs as temperature is increased. In many cases, high operating temperatures can be reduced to normal merely by opening the grease plugs and allowing excess grease to escape.

The effect of the size of the grease pack on the temperature rise of an 80-mm-OD cartridge-type ball bearing, operating at about 3450 rpm, is shown in Table 1. The grease tested was a lime-base lubricant having the consistency of a No. 3 cup grade.

TABLE 1 EFFECT OF SIZE OF GREASE PACK ON BEARING TEMPERATURE RISE

	Film pack	1/3 pack	2/3 pack	Full pack
Equilibrium bearing temperature, deg F	100	102	107	136

It will be observed that four tests were made using film pack (thin grease smear over ball surfaces), 1/3 pack, 2/3 pack, and full pack. In the cases of the film and 1/3-pack bearings, the equilibrium bearing temperature was approximately 101 F. For the full-pack bearing, the temperature leveled off at about 136 F, a difference of 35 F. Considering the fact that chemical reactions double in rate for approximately every 18 F rise in temperature, unnecessarily high operating temperatures, arising from the use of excess lubricant, may decrease markedly the life of the product.

At times it has been stated that the ideal antifriction-bearing grease would be one which would have the same consistency and structure over a broad temperature range; would undergo no excessive structural breakdown under high shearing action; would have low plastic friction; would show no appreciable tendency to sweat oil, to oxidize, or to deteriorate under the conditions of operation; would possess good antiwear and rust-preventive properties; would resist water; and would not aerate even at high operating speeds. Marked progress has been made during the past 5 years toward achieving these objectives. In addition, the manufacturers of bearings have contributed tremendously to lengthening bearing life through improvements in bearing design, metallurgical developments

Contributed by the Machine Design Division and presented at the Annual Meeting, New York, N. Y., November 27–December 2, 1949, of The American Society of Mechanical Engineers.

on bearing metals, and greater uniformity in bearing production.

The principal characteristics of greases, which are usually considered in recommending soap-thickened lubricants for antifriction-bearing applications, will be discussed briefly under the following headings:

1 Consistency.
2 Apparent viscosity.
3 Structural stability at elevated temperatures.
4 Resistance against separation of oil.
5 Chemical stability.
6 Water-resistance and rust-preventive properties.
7 Film strength.

CONSISTENCY

The consistency or hardness of a grease as measured by the ASTM cone penetrometer, is sometimes an indication of the extent to which leakage may occur from an antifriction bearing. For example, in some applications a soft grease, such as a No. 1 cup consistency grade, might be unsuitable because of inadequate seals on the bearings. A grease of the same type, but of heavier consistency, might be satisfactory under these same conditions because of less leakage resulting from the heavier body. It should be emphasized in this connection that consistency in itself, as determined by the ASTM cone penetrometer, gives only meager information regarding the performance properties of a grease in any given antifriction-bearing application. Consistency as determined in this way should be regarded only as a hardness value and should not be employed to predict performance characteristics, such as pumpability or the maximum operating temperature to which the grease might be subjected.

ASTM penetrations are sometimes reported on both unworked and worked samples. The unworked penetration is obtained on the grease after being introduced into a standard cup. This same sample is then worked 60 strokes under prescribed conditions and the penetration is again obtained. The latter value is reported as the worked penetration.

In general, the spread between the unworked and worked penetrations of greases varies 20–100 points. However, some products may break down to an even greater extent, and the spread will fall outside the afore-mentioned range. Other products possessing highly stable structures against shearing action will show very little change after being worked thousands of strokes in a mechanically driven grease worker. This difference in products against structural breakdown by shearing action is illustrated by the data given in Table 2.

TABLE 2 CONSISTENCY VERSUS WORKING

Degree of working	Grease A	Grease B	Grease C
Unworked	210	250	265
Worked 60 times	350	285	270
Worked 1000 times	Semifluid	Semifluid	282
Worked 100,000 times	Semifluid	Semifluid	297

Obviously, the type of product represented by grease A in Table 2 would readily break down in the ball or roller track of an antifriction bearing to a semifluid consistency. Leakage undoubtedly would be high in this case unless effective seals were employed, or unless bearing design were such that excess unworked grease served to seal in the core of semifluid lubricant.

Many of the general-purpose antifriction-bearing greases marketed today will break down to about the extent indicated by grease B. Although this type of product will undergo a moderate breakdown in consistency in antifriction bearings, there is generally no excessive leakage, provided that the bearing speed factor (Speed in rpm × bore of bearing, in.) is less than 8000.

For speed factors higher than 8000, it is usually advisable to employ a grease which will show a stability under shearing action comparable to that of grease C. This type of product generally shows a channeling tendency and lubricates by the mechanism of small particles of grease sloughing off onto the bearing surfaces.

APPARENT VISCOSITY

For years, viscosity has been one of the principal physical characteristics of oils which has been used to guide recommendations for both industrial and automotive applications. Recently a method has been developed for determining readily the viscosities of greases. Unlike oils, the viscosity of a grease is dependent upon the rate of shear or the rate of flow during the determination. The two fundamental differences between the flow characteristics of oils and greases are shown in Fig. 1.

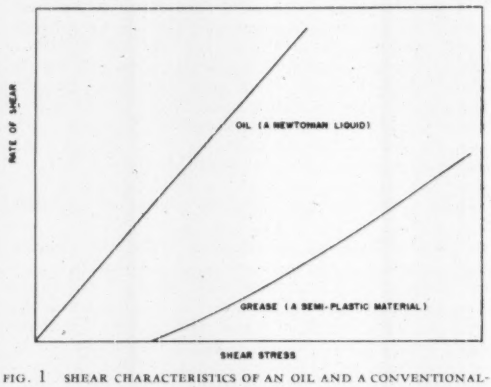


FIG. 1 SHEAR CHARACTERISTICS OF AN OIL AND A CONVENTIONAL-TYPE GREASE

It will be observed that in the case of an oil, or a true Newtonian fluid, the applied force-rate of shear relationship is a straight line which passes through the intersection of the ordinate and abscissa axes. As applied force is increased, rate of shear is increased proportionately. For a grease, however, no proportionate relationship exists. It will be noted further that for a soap-thickened product, a definite force, generally referred to as yield value, must be applied before flow is initiated.

As previously indicated, the viscosity of an oil is independent of rate of shear whereas the viscosity of a grease is dependent thereon. This difference between oils and greases is shown in Table 3.

TABLE 3 COMPARATIVE VISCOSITIES OF AN OIL AND GREASE

	Viscosity in centipoises at 100 F and at a rate of shear of			
	25 sec^{-1}	1000 sec^{-1}	4000 sec^{-1}	10000 sec^{-1}
Oil	50	50	50	50
Lime-base grease (11 per cent soap)	3000	320	210	180

It will be apparent from Table 3 that, as the rate of shear was increased over the range of 25 sec^{-1} to 10,000 sec^{-1}, the viscosity of the oil remained constant. Over the same rate-of-shear range, the viscosity of a lime-base grease, prepared from this oil, decreased from 3000 poises to 180 poises at 100 F.

Generally speaking, the viscosity of a grease decreases as the rate of shear increases. In high-speed antifriction bearings, therefore, grease films which are subjected to indefinitely high shear rates probably have viscosities approaching that of the mineral oil from which the grease is prepared. The changes in viscosities of representative-type greases with an increase in rate of shear are shown in Fig. 2. It will be observed that for the sodium, calcium, and aluminum-base greases tested, the viscosities decreased as the rate of shear increased and approached asymptotically the viscosity of the mineral oil from which the three greases were prepared.

The apparent viscosity of a grease is an important fundamental characteristic and can be used to indicate plastic friction that might be expected in an antifriction bearing at a given temperature and rate of shear. This property also can be employed to predict the ease with which a grease can be pumped. Actually, there is a high correlation between the apparent viscosity of a soap-thickened product and its pumpability properties. For example, the apparent viscosity of a grease at a given temperature and rate of shear will indicate fairly accurately the ease with which the product can be forced from the pump mechanism to the bearings. It is to be noted, however, that such data fail to show the ease with which the product will slump from the grease container down to the pump parts. In other words, although pumpability is predicted by apparent viscosity, slumpability, i.e., the ease with which the grease will slump down in a container and flow to the pump mechanism, is dependent upon the yield value of the product. In general, the unworked penetration of a soap-thickened lubricant can be used as a basis for predicting slumpability properties.

STRUCTURAL STABILITY AT ELEVATED TEMPERATURES

A grease may have many desirable characteristics and yet be unsatisfactory for use in antifriction bearings at elevated temperatures, because of inadequate structural stability. Conventional lime-base greases, for example, are dependent upon a small amount of water, generally about 10 per cent of the soap content, to maintain a smooth buttery type of cup-grease structure. In fact, if this water is lost or is reduced below a certain critical minimum value, the latter depending upon the composition of the particular grease, the lime soap will separate from the lubricant and a heterogeneous mixture of soap and oil will result. For this reason it is necessary to employ a conventional lime-base grease at operating temperatures below which no appreciable amount of water will be lost, as for example 150 F maximum. It should be pointed out in this connection that special types of lime-base greases are currently marketed which are not dependent upon water as a stabilizing agent. These products, in some cases, can be used satisfactorily at temperatures considerably above 200 F.

Although aluminum-base greases require no water as a stabilizing agent, a product of this type should not be used at temperatures much higher than 150 F. An aluminum-stearate grease, the type generally marketed, usually will undergo structural changes at temperatures somewhat higher than 150 F, which will not be reversible unless the grease is cooled very slowly to room temperature. An aluminum-base grease

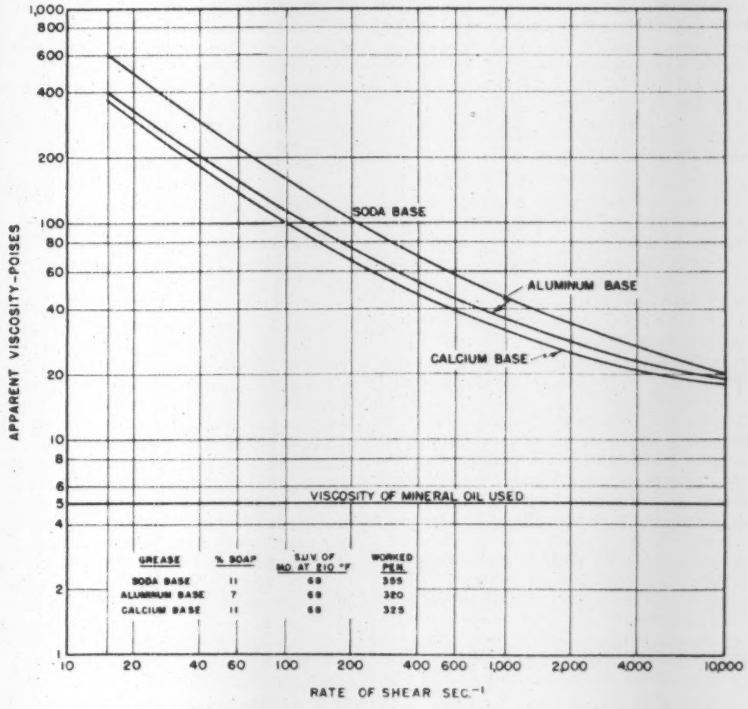


FIG. 2 APPARENT VISCOSITY RATE OF SHEAR RELATIONSHIPS OF THREE GREASES; TEMPERATURE 77 F

having a smooth, buttery structure, for example, may change to a rubbery-type product at about 200 F or higher and, on cooling at a relatively rapid rate from that temperature level to room temperature, become a coarse, hard, unsatisfactory lubricant. For this reason, as in the case of conventional lime-base greases, a structural change resulting from high-temperature treatment limits the use of this type of grease to relatively low operating temperature conditions.

Sodium, lithium, and barium-base greases, generally speaking, have reversible structures and can be employed at temperatures higher than 200 F. Their suitability for continued use at high temperatures will of course depend upon such factors as chemical stability, volatility of mineral-oil component, and the like. It is to be noted that it is not uncommon for sodium-base greases, as well as other greases, to undergo structural changes at elevated temperatures, which may result in the product becoming more fibrous in nature. If this tendency is too pronounced, grease may be thrown from the bearing, if the seals are inadequate, or excessive aeration may occur with subsequent leakage.

Simply as a word of caution, it should be stated that the dropping point of a grease (sometimes incorrectly referred to as melting point) should not be employed as a criterion for indicating performance characteristics of the product at elevated temperatures. If the ASTM dropping point is low, the grease likely will be of a semifluid or fluid consistency at and above the dropping-point temperature. However, if the dropping point is high, it should not be construed that the product necessarily will be a satisfactory high-temperature grease, because such factors as poor chemical stability, undesirable structural changes at critical temperature levels, and so forth, may make the grease unsuitable for use under these conditions. It is significant to note that in ASTM Standards on Petroleum Products and Lubricants, it is stated under Standard Method of Test for Dropping Point of Lubricating Grease, ASTM Designation D506–42, "It (dropping point) should not be considered as having any bearing upon service performance."

RESISTANCE AGAINST SEPARATION OF OIL

Bleeding of a grease in the package is often misinterpreted as definitely predicting that when the grease is packed in bearings, the oil will "run out" and leave the bearings choked with straight soap or very heavy grease. This assumption is not supported by observations in the field unless the grease has been improperly formulated or manufactured. Some years ago such greases might have been encountered, but the manufacture of greases has progressed to the point where the number of products of that extremely poor quality is very small. Today, troubles due to breakdown of grease structure are sometimes incorrectly attributed to bleeding by personnel not familiar with the behavior of greases.

Actually, slight separation of oil in a bearing may be beneficial (1).[1] When greases are employed in many antifriction-bearing applications, as for example in the lubrication of ball bearings of electric motors, a grease which sweats a small amount of oil usually gives better service than one which is "dry" and shows extremely high stability in this respect. The amount of separation referred to of course would be small and would have a negligible effect on consistency in so far as increasing the percentage of soap is concerned. Many consumers of lubricants fail to recognize this fact and erroneously reject greases which have "wet" surfaces and/or which bleed small amounts of oil.

Obviously, if a grease is highly unstable with respect to separation of oil, serious operating difficulties might result: (*a*) In the dispensing of greases, most devices utilize pressure to control rate of flow. If oil separates readily from the grease structure in the greasing appliance, a hard, concentrated soap mixture may build up, which will clog the lines of the equipment and retard or prevent flow of lubricant to the bearing. (*b*) In the antifriction bearing itself, excessive separation of oil may lead to the build-up of hard grease in the bearing recesses which in time will be deleterious.

Both experience and the results of tests which indicate the tendency of greases to separate oil show that the extent of oil separation is influenced by a number of factors. These factors together with brief comments pertaining thereto are as follows:

Grease Structure. The structure of a grease is determined by the nature of its components, as, for example, the type of soap used, and by the procedure employed in its manufacture. Two greases identical in chemical composition may differ widely with respect to resistance against separation, due principally to the degree to which the soap is dispersed in the oil.

Percentage of Soap. In general, the higher the soap content of the grease, the more stable it is with respect to separation.

Viscosity of Mineral Oil. In most cases, the higher the viscosity of the mineral oil used, the greater will be the resistance against separation.

Time. The total amount of separated oil will increase with time, but the rate of separation will decrease as the soap content of the residual grease increases.

Temperature. Increasing temperature generally will increase the rate of separation. For example, a grease usually will separate more oil in a given time at 120 F than at 70 F.

Pressure. Pressure alone, within limits, will produce no marked separation of oil. The application of 3000 psi pressure to a grease in a closed tight container will result in essentially the same amount of separated oil as will occur at atmospheric pressure. The separation of oil from greases while under pressure in application devices, such as automatic cups or power guns, is principally the result of a filtering action or a pressure drop through the grease. A grease may show only slight separation of oil at 3000 psi pressure, and yet bleed 25 per cent of its mineral oil during the same time interval and at the same temperature when placed in an automatic cup at a pressure of less than 10 psi.

Design of Grease Appliance. The design of grease-dispensing equipment, as, for example, the effective clearance of the piston in a power gun, will influence rate of separation.

CHEMICAL STABILITY

Chemical stability of greases has received considerable attention during recent years, since grease life and performance properties are dependent to a large extent upon the resistance which a product possesses against deterioration. The outcome of extensive investigations along this line by grease and bearing manufacturers has led to marked improvements in the chemical stability of antifriction-bearing greases. In fact, these improvements have been largely responsible for the trend toward the adoption of factory prepacked bearings which cannot be serviced without disassembling the machine or equipment. The improvements effected in chemical stability have been accomplished principally through the use of oxidation inhibitors and high-grade raw materials, and by employing improved manufacturing controls to insure uniform production of high-quality products.

The extent to which a grease, or in fact, any petroleum lubricant, will deteriorate in service as a result of chemical reactions is dependent largely upon temperature, time, and the presence of contaminants, such as water, metallic catalysts, and the like. The higher the temperature, the greater the rate of thermal and oxidation reactions. It has been quite definitely established

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

during recent years (2) by infrared and other radiation-absorption techniques that oxidation of an oil or grease results first in the formation of organic peroxides. Subsequently, these peroxides decompose, polymerize, or react with other constituents of the lubricant to form degradation materials, the compositions of which depend upon the test or operating conditions.

When a grease deteriorates in an antifriction bearing as a result of chemical reactions, the grease generally darkens and acquires a rancid or oxidized odor. Simultaneously, organic acids usually develop, being reaction products of oxidation, and the lubricant becomes "acid in reaction." These acids are not, however, necessarily of a corrosive nature, but may have an effect on the grease structure causing a softening or a hardening of the lubricant.

From the foregoing comments it will be apparent that the consumer of antifriction-bearing greases is interested in the degree of chemical stability of a product not only when it is maintained in a quiescent state, as for example in the package or in prepacked stored bearings, but also when it is in a dynamic condition, as in a running bearing. Laboratory tests have been developed to evaluate greases under both conditions.

The storage stability of greases is an important factor determining their merit as lubricants for ball bearings which may be idle for long periods of time, as for example on the shelves of warehouses and in stored machinery. Greases which are defective in this respect have been responsible for large numbers of "frozen" bearings. On disassembling such bearings, it usually will be found that at the points of contact of the balls with the races, corrosion will have occurred, and a considerable amount of oxidized material will have formed. Corrosion may proceed in some cases to the point where the bearings cannot be recovered. In other instances, when the bearings can be broken loose, the extent of the corrosion will be sufficient to cause rough noisy running. There are two methods for evaluating greases in terms of their behavior in prepacked idle bearings. These are known as the "shelf-life test," and the Norma-Hoffmann "oxidation bomb test" (3). Detailed descriptions of these two tests are beyond the scope of this paper.

Numerous types of functional dynamic tests have been developed for evaluating greases under operating conditions which simulate those encountered in actual service. Obviously, data obtained from tests of this type may give valuable information regarding the probable performance characteristics of a grease for a specific application.

WATER-RESISTANCE AND RUST-PREVENTIVE PROPERTIES

In many industrial applications, contamination of the lubricant with water, either by condensation or the ingress of water through bearing seals, is a common occurrence. The term water resistance is often loosely applied in describing the properties which a lubricating grease should have in order to give satisfactory performance when exposure to water occurs. If a grease is readily washed out of a bearing by contact with water, or if the lubricant tends to absorb a relatively large volume of water and expands in volume with subsequent leakage, serious operating difficulties may result.

Many sodium-base greases, particularly those prepared from low-viscosity mineral oils, are "water-soluble," i.e., they tend to disperse in water to form oil-in-water emulsions, and are thereby readily washed from bearings if seals are inadequate. For this reason, the consumer of lubricants often regards sodium-base greases, in general, as having poor water-resistant properties whereas those prepared from calcium, aluminum, lithium, and barium soaps are looked upon as water resistant. Extreme care must be exercised in formulating conclusions in this connection, because some sodium-base greases are quite water-resistant in so far as the formation of oil-in-water dispersions are concerned. To illustrate this fact, it might be pointed out that sodium-base greases are normally satisfactorily employed in the antifriction bearings of car and truck wheels, which are subjected to wet driving conditions through rain and snow.

In considering water-resistant characteristics of greases, it should be borne in mind that soap-thickened lubricants may emulsify to form oil-in-water dispersions, as is the case for sodium-base greases prepared from low-viscosity mineral oils, or may absorb water to form water-in-oil emulsions, as occurs in many cases. If a grease shows a marked tendency to form an oil-in-water emulsion when contacted with water, it will usually be readily washed from an antifriction bearing, particularly if the water is warm. This action is similar to that of a soluble oil or paste when it is admixed with water. On the other hand, if the grease absorbs water to a marked degree to form a water-in-oil dispersion, the volume of lubricant may increase to the point where leakage thereof will be excessive. Generally speaking, the only greases which tend to wash out of bearings to form oil-in-water emulsions are conventional sodium-base lubricants. This tendency is less marked the higher the viscosity of the mineral oil. Calcium, aluminum, lithium, and barium-base greases, and sodium-base greases, prepared from relatively high-viscosity mineral oils, may absorb water to form water-in-oil dispersions. The amount of water which will be taken up by a grease will be dependent not only upon the composition of the product but also upon the degree of homogenization to which the lubricant and water are subjected.

From the foregoing comments it will be apparent that the resistance which a grease in an antifriction bearing exhibits to displacement by water is dependent upon a number of factors. The most important of these factors are as follows (4):

1 Metallic component of soap (sodium, calcium, etc.).
2 Fatty component of soap (oleate, stearate, etc.).
3 Mineral oil (viscosity, degree of refinement, etc.).
4 Reaction of finished grease (free acid or alkali).
5 Additives (rust and oxidation inhibitors, etc.).
6 Bearing design (seals, etc.).
7 Operating conditions (temperature, speed, etc.).

It is to be noted that the effect on consistency, when water contaminates a grease in a revolving bearing, is dependent largely upon grease composition, percentage of water, and conditions of homogenization. In some cases the consistency of the mixture may increase and then decrease as water is incorporated. In other cases, the consistency may decrease progressively. Occasionally, unusual effects on consistency are noted by the addition of water. Mention might be made of the results of an emulsion test which was carried out on a conventional sodium-base wheel-bearing grease. The consistency of the mixture dropped as 80 per cent of water was dispersed in the sample (5 per cent increments) and then the body recovered until about 200 per cent of water was added. When a parallel test was made on the same grease maintained in a flooded condition instead of adding water in small increments, the sample rapidly broke down in consistency to a semifluid, creamy paste.

The constituents of a grease, which determine the extent to which the lubricant will wash out of a bearing to form an oil-in-water emulsion, affect its ability to protect the bearings from rusting when they are exposed to water. Experience has shown that if the grease is to satisfy the objectives of water resistance and rust prevention, some compromise may be necessary because improved rust-preventive properties are usually obtained by favoring the factors which tend to encourage emulsification of oil in water. It has been generally observed that the lubri-

(Continued on page 143)

MAINTENANCE *of* ANTIFRICTION BEARINGS

By J. M. BRUENING

PRESIDENT, OHIO BALL BEARING COMPANY, CLEVELAND, OHIO

ANTIFRICTION bearings, whether of ball or roller construction, are designed into all types of equipment, primarily to perform one or all of the following functions:

1 Reduce friction and starting torque.

2 Increase shaft speeds and shaft accuracies.

3 Transfer wear from shafts and housings to an easily removable and replaceable part, the bearing itself.

Bearings are manufactured in sizes so small that 500 of them are required to fill a thimble, and in sizes so large that a crane is required to move them; an individual bearing in the larger size weighs several tons. These wide diversities in sizes are applied to anything from a variable-pitch propeller on a plane to an exhaust fan in a subway, from high-speed air tools, operating at 200,000 rpm, to the wheels of a baby carriage, from industrial locomotives to steel-mill rollnecks, to mention just a few.

The application of antifriction bearings in the wide variety of sizes and in the diversification of industry presupposes a problem of proper maintenance to insure longest life. It is with the matter of maintenance of antifriction bearings that we shall attempt to deal in this paper.

BASIC RULES OF MAINTENANCE

Obviously, it would be impossible here to deal with specific maintenance problems, but there are simple basic rules which, if observed, will insure the user of the equipment long, uninterrupted, carefree bearing life.

To deal with the bearings themselves, whether of ball or roller construction, it is not generally known that everything in connection with the manufacture of that bearing emphasizes cleanliness. All parts, at all times, prior to assembly, and after assembly into the bearing unit, are handled with the greatest of care with respect to cleanliness.

Of the bearings taken from machinery which we see when replacements are ordered, our experience has shown that dirt is responsible for most failures; dirt which finds its way into the bearing often as a result of carelessness before or during assembly into the unit where it is to function.

The term "dirt," as used in connection with antifriction bearings, generally covers almost any foreign particle—foreign to the bearing itself and/or the lubricant in it. Broadly speaking, there are two classes of such dirt as follows:

1 Abrasive, such as emery, dust, or sand.

2 Obstructive, such as metallic chips or sawdust.

Ball bearings rolling in their raceways, which closely conform to the contour of the balls themselves, have a contact which often is under high pressure. Consequently, abrasive dirt (hard particles that cannot be washed or blown out), when mixed with lubricant, forms a lapping compound capable of destroying the fit-up and accuracy of the bearing.

Obstructive dirt destroys efficiency of the bearing at the outset, by impeding normal rotation of the balls, causing heat and skidding, and early bearing failure; obstructive dirt can even cause breakage of the ball retainer, or it can cause the bearing to seize, by reason of the raceways becoming smeared with metal chips. It can cause vibrations reflected in the finish and appearance of the work.

PRECAUTIONS TAKEN TO ASSURE CLEAN BEARINGS

The various bearing manufacturers have invested thousands of dollars in elaborate equipment and methods to insure clean bearings. In the case of certain bearing companies, final washing, greasing, wrapping, and packaging are done in filtered and air-conditioned rooms. Slushing compounds and the grease with which bearings are packed are thoroughly filtered. Employees who handle bearings in the final stages of inspection even use special hand creams, to prevent rust from perspiration.

Such great care is taken because the bearing becomes the vital part of the machine in which it is installed to enable accuracy in mass production. When properly applied, the bearing enables that machine to mass produce with accuracy, speed, and freedom from trouble.

Bearings leave the factories carefully wrapped, boxed, and sealed with the containers clearly showing the number. When placed into stock, it should be the rule that the new bearings are arranged so older or prior lots are used first. Bearings should not be unwrapped until ready for installation. To be ready for installation—since we are dealing with bearings being applied to shafts and housings where a prior bearing has functioned—it is necessary to observe the following:

Make certain the bearing seat is clean—no burrs, roughness, or scoring—and that the shaft is not undersize, a condition which can obtain if the bearing being replaced has locked, consequently turned on the shaft.

Mounting a bearing on an unclean shaft usually means that dirt (previously discussed) will be trapped between the shaft and shoulder of the bearing, which will prevent accurate seating. If the seat is of the correct diameter, the bearing should go all the way to the shoulder smoothly and with uniform pressure. If it sticks at any point, the bearing may be cocked. A cocked bearing will bind and cause early failure. Do not force a bearing, which has not started squarely onto the shaft, as it may scrape and damage the shaft. Do not force a bearing onto a shaft by pressure exerted on the outer ring as there is risk of brinelling the raceways. Shaft shoulders and fillets are as vital to bearing performance as correct bearing-seat diameters, since the bearing actually is squared up when pushed against the shoulder. Thus the squareness of the bearing is determined by the squareness of the shoulder.

The proper operation of all running parts, and shaft or spindle

Contributed by the Machine Design Division and presented at the Annual Meeting, New York, N. Y., November 27–December 2, 1949, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

depends so greatly on the bearing, that it is just good business to see that the bearing is mounted with the greatest of care.

Provide a clean assembly bench; particularly if the workbench is of wood it may be impregnated with filings, chips, and other dirt. An easy remedy is to lay the unwrapped bearing on a clean paper placed on top of the bench. The bearing, if new and just removed from its box and wrapper, should not be washed out. The slush or grease in a bearing was put there by the manufacturer for a definite purpose and is clean.

WASHING BEARINGS

Frequently, bearings are removed while overhauling a piece of equipment, and may be cleaned and returned for further usage. A few suggestions for cleaning follow:

There is a great temptation to spin the bearing thus removed to see how it runs or sounds. This spinning is ruinous to the bearing for the dirt can easily drop into the races, scratching the balls and raceways, shortening life expectancy of the bearing accordingly.

Put the bearings in a clean container. Kerosene may be used for cleaning, although carbon tetrachloride or Stoddard "B" are preferred. If the bearing is quite dirt-caked, it may be necessary to soak it for 24 hours and to use a short-bristled brush to loosen the foreign material in it. Swish the bearings in the cleaner and, while submerged, revolve it by hand to remove all grease, oil, or dirt.

After cleaning, rinse it in clean solvent, dip it in light oil (as solvents such as tetrachloride leave surfaces quite susceptible to rust). Always lubricate immediately after the bearings have been cleaned and washed. An air hose helps in cleaning bearings, but the bearing rings must be kept from spinning, otherwise dirt particles may cause scoring. As a further precaution, the air line should be filtered.

If the bearings are to be returned to stock, having been coated with a high-grade oil or petrolatum, they should be wrapped in oil paper or cellophane before being placed in boxes.

If the bearing is placed in a box without being wrapped, the lubricant soaks into the box, leaving the bearing dry and likely to corrode.

ORDERING REPLACEMENTS

In connection with ordering bearings for maintenance of a piece of equipment, always tell the supplier the application for which the bearings are intended. There is a difference in precision and assembly of antifriction bearings carrying the same part number.

For example, ball and straight roller types have varying degrees of precision on runout, and of ball or roller clearance, depending upon the application for which they are used.

Tapered roller bearings likewise are made in different degrees of precision on runout. In ordering bearings, specify not only the bearing make and part number, but the make and type of machine and position of application so that the correct bearings can be supplied for the purpose.

Antifriction bearings are both rugged and delicate. They will withstand for long periods the punishment imposed by the service for which they are designed, when they have been properly applied.

TRADE LITERATURE ON CARE OF BEARINGS

A number of excellent papers have been prepared and are available from the manufacturers dealing with the care of antifriction bearings, embracing practically all that can be said on the subject. These are as follows:

"When Handling Ball Bearings," Reprint from *The Fafnir Dragon*, The Fafnir Bearing Company, New Britain, Conn.

"How to Get Longer Life From Anti-Friction Bearings," by G. Palmgren, Chief Engineer, SKF Industries, Inc., Philadelphia, Pa., reprint from *Factory Management and Maintenance*.

"Bearing Failures and Their Causes," All-Inclusive Pamphlet with illustrations. SKF Industries, Inc., Philadelphia, Pa. This treatise covers ball bearings, roller bearings, and thrust bearings.

"N.D. Form NDA-307 Ball Bearing Mounting and Maintenance Practice," New Departure Industrial Shop Manual, New Departure Manufacturing Company, Bristol, Conn.

Characteristics of Greases as Related to Antifriction Bearing Applications

(Continued from page 141)

cant, to be an effective rust preventive, must contain a component which will preferentially wet the bearing surfaces in the presence of moisture and/or promote the formation of the required type of emulsion.

Generally speaking, highly water-resistant greases will show poor rust-preventive characteristics when water is present (5). Soda-base greases usually have good rust-preventive properties, but, obviously, if the water solubility of the product is high, it may be washed entirely from the bearing and not be present to protect metallic surfaces against the corrosive action of water. Rust-preventive properties of greases definitely are tied in with composition, and the properties of greases in this respect may be markedly modified through the addition of small amounts of surface-active rust-preventive materials.

FILM-STRENGTH CHARACTERISTICS

For most antifriction-bearing applications, straight greases, i.e., those without added film-strength-improving agents, are adequate in so far as preventing metal-to-metal contact is concerned. However, when loads are abnormally high and rupture of the grease film might occur, it is usually necessary to add to the product, at the time of manufacture, a material that will improve its film-strength properties. Additives for this purpose generally contain chlorine, sulphur, phosphorus, lead, or a combination thereof as the active chemical element or elements.

The mechanism whereby film-strength-improving agents function in greases is essentially the same as that for the performance of similar-type materials in lubricating oils. Under conditions of relatively high bearing-surface temperature, which usually result when rupture of the grease film is imminent, the active components of such lubricants may combine chemically with the bearing surfaces to form films that will minimize or prevent metal-to-metal contact. In the case of steel-on-steel, for example, the film thus formed might be an iron sulphide having a shear strength lower than that of iron and a melting point of approximately 2000 F. Under conditions of shock or heavy loads, this film would withstand higher pressures before rupture than a grease film and would afford increased protection against scoring of the steel surfaces.

It is to be noted that not all extreme-pressure agents are suitable for use in antifriction-bearing applications because of their

corrosivity, particularly when water is present. For this reason, it is necessary to select a film-strength-improving material for a given application that will be satisfactory under the operating conditions to which the grease will be subjected. If the additive material promotes corrosion of the bearing surfaces, relatively short bearing life can be expected.

The question is sometimes raised as to why greases containing extreme pressure ingredients are not employed widely for most antifriction-bearing applications, since the film-strength properties thereof are markedly superior. The principal reason for limiting the use of such products only to those applications where they are required is because, in general, they are inferior in chemical stability to high-quality straight greases. It would not be considered advisable, for example, to recommend an extreme pressure grease for use in a "packed-for-life" bearing. Broadly speaking, this type of grease should be employed only in applications wherebearing-load requirements necessitate its use.

SUMMARY

A brief review has been made of the principal characteristics of greases which should be taken into account in the recommendation of products for antifriction-bearing applications. No attempt has been made to include a discussion of all factors which may affect performance properties. In general, a complete understanding of the over-all characteristics of the lubricant and detailed information regarding operating conditions are required to indicate with reasonable accuracy the suitability of a grease for any given antifriction-bearing use.

BIBLIOGRAPHY

1 "The Effect of Soap Structures on Apparent Viscosities of Lubricating Greases," by T. G. Roehner and R. C. Robinson, *The Institute Spokesman*, vol. 10, no. 12, 1947, p. 4.

2 "Oxidation," by E. H. Farmer and A. Sundralingam, Transactions of the Faraday Society, Discussion, 1945.

3 ABEC-NLGI Technical Bulletin no. 6, 1946.

4 "Evaluation of Water Resistance Properties of Lubricating Greases," by T. G. Roehner and E. S. Carmichael, *The Institute Spokesman*, vol. 11, no. 6, 1947, p. 5.

5 "Amphibian Wheel Bearing Grease," Coordinating Research Council's Report no. CRC-206, 1946.

The Outlook for Ceramics in Gas Turbines

(*Continued from page 130*)

of metals such as tantalum, molybdenum, and tungsten by hydrogen reduction or thermal decomposition of their chlorides or bromides, the formation of coatings of silicon carbide, titanium carbide, tantalum carbide, and the like, by the reaction of their chlorides with a hydrocarbon-hydrogen atmosphere, and the formation of silicide coatings by the reaction of silicon tetrachloride-hydrogen atmosphere with a refractory metal base.

A wide variety of chemical reactions is available for formation of protective coatings by vapor-deposition techniques. Coatings of all of the refractory metals, carbides, borides, silicides, oxides, and nitrides can be obtained by one or more of these processes.

Obviously, many of the refractory materials are quite brittle, and differences between their coefficients of expansion and that of a given base may restrict their use. In many cases, however, by proper selection of coating and base materials, increased service life is obtained.

Vapor-deposition processes also can be used to coat ceramic materials such as graphite, alumina, zirconia, and tungsten carbide.

Much of the work on commercial application of vapor-deposition processes is unpublished; hence the application of specific coatings to gas turbines cannot be discussed here. It is important to note, however, that these processes are available, that they are extremely versatile, and that consideration should be given to them where commercial processes are either unavailable or inadequate.

Perhaps the outstanding development on vapor-deposition processes is the development of protective coatings for molybdenum, which have permitted its use in air for over 5000 hr at 1800 F, and as long as 500 hr at 3100 F. In a number of tests for short-time applications in extreme high-temperature flames, molybdenum so protected has given outstanding performance.

Examples of coatings of potential interest are silicon or silicon carbide on graphite for oxidation resistance, boron carbide on graphite and other ceramic materials for wear resistance, and refractory metals, such as tungsten and tantalum, on other metals for heat and erosion resistance under nonoxidizing conditions.

Coatings applied by vapor-deposition methods normally are of theoretical density, and, although subject to localized imperfections if improperly applied, are nonporous as deposited. Hence an outstanding advantage of these processes is that no heat-treating is necessary to obtain a continuous coating. Therefore the coating need not be limited by a maturing temperature which, in turn, is limited by the heat resistance of the base metal. An additional advantage of vapor-deposition coatings is that coatings formed at a high temperature are frequently more stable, at high temperatures, than those formed at room temperature.

CONCLUSIONS

From the standpoint of pure ceramic technology, rapid advances have been made within the past few years in ceramic research relevant to gas turbines. Even so, there are many uninvestigated raw materials and combinations of raw materials from which better gas-turbine components might be made. Also, much remains to be learned about the mechanism of sintering in glass-free ceramic materials.

In general, several available ceramic materials might serve advantageously for parts operating in the hot zones of gas turbines. Coatings for metals seem particularly attractive for immediate use, while ceramic bodies might afford more outstanding benefits. Design or operational adjustments often may be necessary to obtain maximum performance from ceramic bodies.

To evaluate and to use all types of ceramic materials, close co-operation is required between ceramists and gas-turbine engineers. With this co-operation, gas turbines with higher operating temperatures, longer life, or both, and, perhaps, lower weight seem within the realm of not-too-distant possibilities.

JOB SATISFACTION *and* LABOR MOBILITY[1]

By GEORGE P. SHULTZ

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS.

EFFECTIVE use of our man-power resources is an important social objective, one which has been brought forcibly to our attention during the war and postwar periods of full employment and labor scarcity. To bring about and maintain an optimum allocation of the labor force, so that workers are devoting their efforts to the goods which the public wants most, individuals must be able to find out about alternative job opportunities and they must be willing to move from one job to another when a more attractive alternative is available. In other words, we have a continuing need for a functioning labor market, for movement of workers away from declining industries and occupations and into industries and occupations that are expanding.

Economists, traditionally concerned with the problem of resource allocation, have long been interested in the question of labor mobility, and they have focused their attention on the wage rate as a means of attracting and holding workers in a given occupation. More recently, however, students of human relations have emphasized the influence of nonwage employment conditions on worker behavior. Partly as a result of these observations, further studies have been made of the job market as seen by the worker and of the satisfactions which seem important to him, as he considers the relative merits of alternative job opportunities.

A more realistic understanding of this aspect of worker behavior would, of course, be of great value to the factory manager. As he faces daily problems of recruiting, selecting, and training, and of holding turnover and absenteeism to a minimum, he is obliged to act on some theory of what will attract workers to his plant and what will keep them satisfied with their jobs after they have been hired. Does his theory square with the facts? Or is he acting on false assumptions, which are, therefore, a continual drain on his company's resources?

A recent study of the problems of labor mobility and job satisfaction was made by Lloyd G. Reynolds and Joseph Shister of the Yale University Labor and Management Center and their findings are presented in a book[2] entitled "Job Horizons." The data on which they base their observations result from intensive, fixed-question-free-answer interviews with about eight hundred manual workers in a medium-sized New England city during the year 1947. The authors divide their material into three areas of interest, which they identify by the following questions:

1 "How do workers locate and select new jobs? What do they know about wages and conditions in various plants in the area, and how do they hear about vacancies in these plants? Do they make a systematic canvass of the labor market and compare the merits of different jobs before reaching a decision? If so, on what basis do they choose one job instead of another? To what extent do they use organized placement agencies such as the State Employment Service?

2 "What determines whether the worker will stay on the job after he is hired? On what basis does he decide whether the job is good or bad? What things about the job are most likely to make him dissatisfied to the point of quitting? How important are wages as compared with nonwage characteristics of the job?

3 "What kind of occupational plans and ambitions do workers have for the future? How many industrial workers are content with the jobs they are doing and have no desire for change? What methods of self-advancement do they use, and what are the chief obstacles they encounter?"

Reynolds and Shister conclude that the worker typically chooses his job on anything but a systematic basis. His knowledge, first of all, of comparative wage rates and conditions of employment was found to be "so meager that they (the results of interview questions on this subject) were not considered worth tabulating." In fact, the employed worker, far from having his eyes continuously open for something better, was "not interested in other jobs, even though some of these might appear better to an outside observer." As one is quoted as explaining by analogy, "A man who is happily married doesn't keep comparing his wife with every girl he meets on the street." Even in the case of the worker actively looking for employment, moreover, jobs seem to be selected "one at a time," with a strong tendency toward taking the first one offered.

This lack of knowledge of the labor market is, in part, attributable to the informal and casual way in which workers find out about job opportunities. Their principal sources of information were found to be friends and relatives, on the one hand, and random application at the plant, on the other.[3] The services of the State Employment Service were used by only 13 per cent of the workers interviewed as a method of learning about their present job. Why is it that the SES was not a more effective clearinghouse for information about the labor market? The Service was found to be caught in a "vicious circle." Employers fill the best jobs easily by private recruitment, so that only the unattractive ones are listed with the SES. The best workers then fend for themselves since they feel that the "only jobs they have down there are the jobs that no one wants anyway." Thus, as the authors point out, "Through no fault of its own, the Service is confronted with 'hard-to-fill' jobs on the one side and 'hard-to-place' workers on the other."

This picture of a chaotic labor market, especially with respect to the worker's lack of response to wage differentials as between firms, is emphasized by Reynolds and Shister's findings as to the relative unimportance of wages as an element in job satisfaction. For example, of those who were dissatisfied with their present job, only about one fourth gave wages as the reason. Taken collectively, the dominant influences on the worker's attitude toward his job were not connected with money income. More important were the physical char-

[1] One of a series of reviews of current economic literature affecting engineering, prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

[2] "Job Horizons," by Lloyd G. Reynolds and Joseph Shister, Harper and Bros., New York, N. Y., 1949, 102 pp.

[3] These informal methods of finding jobs were found to be very important in an earlier labor-market study, "The Movement of Factory Workers," by W. R. Maclaurin and C. A. Myers, The Technology Press, New York, N. Y., 1943, pp. 25–33.

acteristics of the job: independence from close supervision and some control over the work environment, fairness of treatment, and job interest. However, this scale of the importance of various factors for job satisfaction must, as the authors point out, be related to the general level of employment and business conditions. Thus the fact that none of the workers interviewed gave lack of security as the reason for dissatisfaction with their job must be placed alongside the facts of full employment and generally prosperous business in 1947. If the same workers were interviewed during a period of substantial unemployment, job security might well become the dominant influence on worker attitudes.[4]

The individuals studied in this survey had made a considerable amount of occupational progress during their working lives. For example, of those who started in unskilled jobs, 29 per cent had progressed to skilled and 38 per cent to semiskilled occupations, and of those who started as apprentices, 63 per cent had moved up to a skilled job. Their occupational horizons, however, were definitely limited, only a small fraction of them falling into the category "Would like to move up and expects to," with the bulk of the workers classified as "Would like to move but does not expect to," or "Prefers to remain on present job." The principal obstacle which workers who wanted better jobs saw as blocking their progress was the lack of vacancies in the occupations to which they aspired, though they felt their own incompetence and their age to be additional important factors. It may be interesting to note that discrimination by management in promotions appeared as a block to only a small minority of the workers.

In explaining the fact that many individuals expressed no desire to improve their occupational status, the authors note a general reluctance to undertake the job of foreman. Why is it that this job has become so unattractive? One of the worker's comments is most revealing: "Oh, I guess I could get a foremanship. I've been a foreman already but I don't care for it. If you're a foreman you've got to get so much work out of men; if you know a man is holding out you've got to push him along. When you do that that makes you a no-good guy with the other men. I don't like that. I like to be respected by my fellow workers."

While in some cases men turned down a supervisory position because they did not want the consequent responsibility, others felt that the foreman did not have much of a job, but was really "just a sort of message boy." These comments indicate that the "foreman problem" so much discussed in industry today may better be tackled on the organizational and recruitment level than on the level of training.

The worker's view of job opportunity, then, is far different from a theory which emphasizes choice among several alternatives, adequate knowledge about the labor market, foresight, initiative, and economic motivation. The worker is pictured as finding out about his job in a more or less haphazard manner and choosing on the basis of a fragmentary and inadequate knowledge of the labor market. Thus, as the authors state, "If one were trying to predict the plant in which an unemployed man will seek work, it would be more important to know where his friends and relatives are working than to know the wage levels of different plants in the area." Once on the job, furthermore, the worker does not keep his eyes always open for other opportunities nor does he set his hopes for advancement too high. On the contrary, if the job is not too disagreeable from a physical standpoint and has some intrinsic interest, if the worker is not pressed too hard by supervision and is given fair treatment by his foremen, and if he gets along with the other workers in his department, he is likely to stay on his job, despite apparently more favorable openings elsewhere.

The authors are careful to specify that their conclusions apply only "as jobs were set up in this area in 1947." Certainly, the relative importance of the various factors in job satisfaction is likely to change where the economic environment places the worker's money income in more jeopardy than it was in 1947. Other labor-market studies, however, have confirmed the point that job choices are made in a very unsystematic manner and that therefore the labor market functions only imperfectly as a means of directing our manpower resources into their most effective uses. This description, of course, does not tell us what, if anything, may be done to improve the operation of the labor market; however, our thinking about this problem can at least spring from a more realistic appraisal of job opportunities as the worker sees them.

[4] This hypothesis is confirmed by a forthcoming study made of a New England labor surplus area in 1949. The study was made as part of the work of the Industrial Relations Section at the Massachusetts Institute of Technology and under the direction of Charles A. Myers and George P. Shultz.

Nuclear Reactor Training

ADVANCED training in the field of reactor development will be given government and industrial scientists and engineers at a newly established Atomic Energy Commission Reactor Development Training School at the Oak Ridge National Laboratory.

The emphasis on the new school will be to supply as quickly as possible scientists and engineers with formal training in reactor development. The students will fall into the following three categories:

1 Engineers from industrial organizations who will remain on their companies' pay rolls while attending the school.

2 Employees of other atomic-energy laboratories or other government agencies detailed to Oak Ridge for training.

3 Recent college graduates hired by Oak Ridge National Laboratory who will be trained as regular employees and will then be available for transfer to reactor groups throughout the atomic-energy program.

Present plans call for about 60 students to be trained at one time, about 30 students in categories 1 and 2, and an additional 30 in category 3. The school will operate continuously. All students will be required to have complete security investigation and clearance and the lectures and study material will be classified. Selection will be made by the Commission from qualified applicants on the basis of the need of the organization with whom its applicant is affiliated for personnel trained in reactor development, its potential contribution of the applicant to the AEC programs, and his academic record.

Industrial participation is an important part of the training program since many American industrial concerns are working under AEC contracts on one or more phases of reactor development. In addition, many industrial companies of potential value to the national reactor-development program have been unable to undertake work in the field because of their lack of men with the necessary training.

Plans for industrial participation are in accord with proposals made to the Commission by professional and engineering groups to provide opportunities for selected industrial organizations to send working-level engineers to atomic-energy installations for firsthand experience and training.

Dr. F. C. VonderLage, former director of the training division of the Oak Ridge National Laboratory, has been named the director of the Reactor Training School.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

Compiled and Edited by J. J. Jaklitsch, Jr.

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Small-Plant Management

MEANS of increasing the productive efficiency of small businesses were discussed by Frank K. Shallenberger, associate professor, Graduate School of Business, Stanford University, Calif., during the 1949 ASME Semi-Annual Meeting, held in San Francisco, Calif. He pointed out that past studies have emphasized the small businessman's sales, finance, purchasing, or tax problems, and have largely neglected his production problems. Less than ten per cent of small business is engaged in manufacturing, but for these companies, the efficient fulfillment of the production function is of major importance.

Professor Shallenberger cited production control as probably the most important of the nonoperating functions. Yet its advantages are largely overlooked in many small companies, apparently because of the production man's natural aversion to paper work and his confidence in personal contact as a means of control.

In many small plants, work orders are made out against sales and forwarded to the superintendent. When the shop worker completes an assignment, the superintendent selects a job for him from the pile of work orders on his desk. There is an element of control here, in that the superintendent gives some recognition to the relative priority of the various orders, has a familiarity with the workers' abilities, and knows what machines happen to be available. But there is little or no advance planning, scheduling, attempt to combine orders for more economical manufacture, assurance that the materials will be available for the worker, or means of foreseeing or forestalling trouble before it occurs. Raw materials may rest on shelves or float about the shop until lost or obsolete; half-completed work in process may occupy plant floor space and tie up working capital for weeks while missing parts are located or produced; operations are performed in wasteful sequence and machines are torn down in the middle of a run to make way for orders of higher priority; men and machines are intermittently idle; delivery dates are broken; expediting and trouble shooting are frequent and costly.

It is the objective of production control to minimize such wastes, to provide an orderly flow of work from raw materials to finished goods, to permit the most effective use of production facilities. For the small plant the program need be neither complex nor expensive. Production control is a simple and logical technique involving planning, to develop the over-all manufacturing program; routing, to provide the most efficient sequence of operations; scheduling, to determine when each operation should be performed in order to insure an orderly flow of production and effective utilization of facilities; dispatching, to assign work to operating departments in accordance with the schedule; and follow-up, to indicate variation from planned operation in time to take remedial action.

To a large extent, the production-control system must be tailor-made for the individual plant. The company manufacturing a simple standard product on a continuous basis can schedule deliveries of materials and plan its shop routings and manufacturing schedules far in advance. Production control then becomes largely a matter of insuring compliance with these schedules anticipating delays before they can shut down operations, varying schedules in accordance with fluctuations in sales and recording data for cost control, and for more effective planning in the future. For the company manufacturing a variety of products on a lot basis, or the jobbing shop producing in long runs, the most important problem is that of insuring a balanced and co-ordinated flow of materials up to the scheduled delivery date. A simple schedule of work ahead, perhaps only a blackboard, is the most practical means of meeting this problem. The schedule should include breakdowns of lead times showing for each part when engineering, purchase orders, patterns, tooling, and materials should be released, and when each operation must be scheduled to guarantee a unified flow of component parts and promised delivery. The board should also provide for charting each order's progress toward completion. The addition of a departmental chart will help avoid overloading and indicate possibilities of bringing in outside work to utilize chronically idle punch presses, grinders, or other specialized pieces of equipment. The job-order shop making only one or two units on each order should likewise preplan and schedule its operation to insure parts and materials availability, to provide a basis for evaluating actual performance, and to improve estimating. However, such a

How to Obtain Further Information on "Briefing the Record" Items

MATERIAL for this section is abstracted from: (1) technical magazines; (2) news stories and releases of manufacturers, Government agencies, and other institutions; and (3) ASME technical papers not preprinted for meetings. Abstracts of ASME preprints will be found in the "ASME Technical Digest" section.

For the texts from which the abstracts of the "Briefing the Record" section are prepared, the reader is referred to the original sources: i.e., (1) The technical magazine mentioned in the abstract, which is on file in the Engineering Societies Library, 29 West 39th St., New York 18, N. Y., and other libraries. (2) The manufacturer, Government agency, or other institution referred to in the abstract. (3) The Engineering Societies Library for ASME papers not preprinted for meetings. Only the original manuscripts of these papers are available. Photostat copies may be purchased from the Library at usual rates, 40 cents per page.

plant must place greater reliance on personal supervision and employee judgment.

Other functions such as stores control, quality control, cost control, and tooling, performance standards, and plant layout were also discussed by Professor Shallenberger.

To a large extent the responsibility for carrying out these functions must be borne by regular line personnel. The foreman must share in the responsibility for production, quality and cost control, for improvement of methods, for establishing performance standards, for housekeeping, and for safety. This combination of line and staff responsibilities may violate certain accepted management doctrines, but the small plant simply cannot afford a separate group of control and technical specialists. Moreover, participation in these functions will instill in line personnel an understanding of the value of controls and their necessary paper work, a consciousness of costs, a better appreciation of management objectives. With their regular duties simplified as a result of management controls, line personnel should be able to assume these extra burdens.

To obtain help in developing suitable control procedures, the small business operator will generally have to seek outside advice. Potential sources of such assistance are as follows:

The management consultant may be the logical source of assistance. Consulting service is expensive, and the small concern should prepare itself for consulting by exploring the situation and marshaling all pertinent facts prior to the arrival of the consultant. This in itself may point to a solution. Many companies would be well-advised to engage a reputable consultant to spend a day or two in the plant, calling attention to the more obvious deficiencies and outlining means of improving operating efficiency and control.

Banks can serve as a catalyst in recommending other sources of technical assistance, but their direct value in the production area is somewhat doubtful.

Suppliers are one of the most promising sources of assistance in product development, materials, methods, processes, equipment, layout, and even performance standards. Sales and research engineers of suppliers are now more than ever available to provide individual technical assistance. The small company which does not utilize such services misses a valuable opportunity.

The Federal Government, through the Department of Commerce, offers an advisory service to small plants. This agency publishes pamphlets written in easily understood terms and reprints of magazine articles relating to specific industries or special problems, such as methods, cost control, plant location, patent protection, wage incentives, organization, and safety. Most of these are available without charge through regional offices.

Technical societies, such as The American Society of Mechanical Engineers, provide an exceptionally good opportunity for the manager of the small business to discuss operating problems with others who have experience, ability, and an active interest in production problems. Round-table sessions conducted by such groups offer excellent practical instruction, and the regular meetings provide a management perspective frequently missing in the small concern. The publications of these societies, as well as various trade papers, provide thoughtful discussion of management problems and practical information on current technical developments.

Some unions, such as the International Ladies Garment Workers, maintain management-engineering sections, one of whose functions is to aid employers, particularly small companies, in increasing plant efficiency.

Educational institutions have an opportunity and an obligation to contribute toward improved management in small business. In the past they have emphasized research and training in the management problems of large concerns.

A final approach to the small businessman's problem of fulfilling staff functions without benefit of staff organization lies in employing a single individual trained in all these functions —a sort of "manufacturing controller." This is not for the plant of two or three employees, but for the concern of 25 or 30 or more. This individual could assume responsibility for organizing and administering all the necessary control systems. He would be responsible for scheduling work and for maintaining production-control charts, for supervising stores control, for confirming delivery dates, and for accumulating and digesting cost data for the owner-manager. He could handle the organization of the methods-improvement program, superintend the development of performance standards, and be responsible for the training and maintenance of records pertinent to these programs. He could provide organization "backup" for the owner-manager and substitute for him when necessary.

This would be a management position, the prime requisite being a broad practical training in the administration and control of manufacturing. Actual plant experience would be of great value; so would an understanding of industrial engineering. The man with broad management training could augment the owner-manager's limited background in sales, finance, accounting, statistics, or industrial relations. The most logical candidate for this position is the man who has majored in production management at an accredited school of business administration, particularly a graduate school, where competition is more severe and training more intensive. Most of the current graduates of these schools are ex-G.I.'s whose age and military experience have developed a mature, practical judgment not ordinarily found in younger men. Many such men would be attracted by the variety of work, the immediate responsibilities, and the excitement of the small concern. Many small companies would derive benefits far outweighing the cost of adding such a man to their staffs.

Rubber Roads

SUPPLEMENTING the article on "Rubber-Top Roads," published on pages 1043 and 1044, of the December, 1949, issue of MECHANICAL ENGINEERING, Harry K. Fisher, rubber road consultant of the Natural Rubber Bureau, Washington, D. C., writes that mixing rubber with asphalt is not of recent origin. During the past fifty years, states Mr. Fisher, many experiments of this character have been made by scientists of various nations. As a result of these early experiments rubber mixed with asphalt is now in use in many commercial products. Until recently it has not been possible to get completely satisfactory results when mixing rubber with asphalt for paving purposes. The advent of unprocessed-natural-rubber particles gave the first indication of worth-while improvement to highway paving where the rubber was added to asphaltic paving material.

For the past twelve years paving engineers of The Netherlands and of Java have been experimenting with natural-rubber particles mixed with asphaltic paving material. The rubber was mixed with regular asphaltic paving mixtures. The natural rubber was added in varying percentages according to the type of aggregate and asphalt used.

In The Netherlands, also in Java, rubber-asphalt paving has been in place, in several locations, for a period of twelve years. One stretch of this type of paving is on a very heavily traveled road outside of Rotterdam, The Netherlands. The German Army used this highway in its invasion of The Netherlands and the American Army used it in pushing the Germans back

out of this country. The road has been subjected to unusually heavy traffic and of a type that should have caused considerable damage to the pavement. This did not occur. Today the pavement is in very good condition and has required no maintenance.

American highway engineers are always on the alert for new construction ideas that will prolong the life of highway paving or lower maintenance costs. Naturally, considerable attention is being given to the recent rubber-asphalt paving experiments. In the United States paving engineers are experimenting with synthetic and reclaimed rubber particles in addition to the unprocessed natural rubber particles which were used in The Netherlands and Java paving projects. Natural rubber was used in highway experimental paving in Ohio, Virginia, Minnesota, and Texas, also Canada. The State of Massachusetts will lay natural rubber-asphalt paving in the spring of 1950.

According to Mr. Fisher, test results to date indicate that natural rubber added to asphaltic paving material increases the life of the pavement, requires less maintenance, increases the elasticity of the pavement, reduces temperature variations, thereby permitting a softer pavement at low temperatures and a harder pavement at high temperatures; it greatly reduces brittleness at low temperatures and materially increases the coefficient of friction of the surface area. The destructive effect of traffic shock and vibration is materially reduced when natural rubber is used in the asphaltic pavement.

Experiments in the United States were made using the regular paving specifications customarily used for high-type asphaltic paving. In some cases the rubber is added to the asphalt prior to mixing with the aggregate. In other cases the rubber is added to the aggregate just after the aggregate enters the mixing chamber of the asphalt plant and prior to the introduction of the asphalt. No difficulties have been experienced in mixing, laying, or rolling the natural rubber-asphalt paving materials. The softening point and the viscosity of the asphalt is slightly increased. There are good possibilities that natural rubber added to asphaltic paving will result in savings, through increasing pavement life and lowering maintenance cost, amounting to several hundred million dollars yearly.

Air-to-Air Missile

THE USAF'S first air-to-air guided missile, the Ryan Aeronautical Company's "Firebird," was described in the December, 1949, issue of the *Technical Data Digest*. This new rocket-propelled missile is virtually a fragmentation shell with near-human intelligence. It is extremely small, fast, and difficult to track even on radarscopes. Since visual sighting is not required, the Firebird is designed to be as effective for night and inclement-weather interception as in clear skies.

Extremely compact for the complete radar navigational system and large explosive charge it carries, it is launched from a "mother" jet fighter and it is capable of heading off destroying its objective in a matter of seconds. It has all the speed first generated by the parent fighter, the added power of its own booster rocket, and finally its flight rocket.

Because it is a pilotless projectile, it is capable of maneuvers normally beyond human endurance, and this makes it extremely effective against piloted craft. Just a little over 6 in. in diam, the Firebird is 10 ft long normally, and only $7\frac{1}{2}$ ft long after its booster rocket is dropped.

The missile's mother plane is the first to detect the target, and directs the launching of the projectile. Thereafter, the Firebird is designed to "home" on the enemy target. At night or in bad weather the launch plane must have a search-tracking radar capable of spotting the enemy plane.

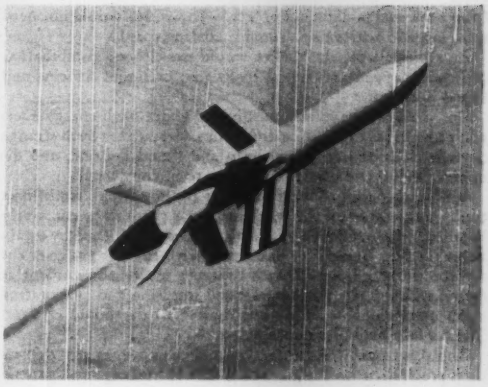


FIG. 1 RYAN FIREBIRD IN FLIGHT

One or more of the missiles can be carried on external launching racks which fit standard bomb installations, and they can be fired singly or in pairs. In actual flight tests, four of the Firebird air-to-air missiles were slung beneath the wings of a North America F-82—two under each wing. In other tests, a Douglas B-26 served as the launch plane.

The wings and tail of the missile are in the form of a double cruciform, the wings having an X attitude and the fins a + attitude when in level flight. The four vanelike wings are located about midway on the rocket portion of the projectile. The four tail vanes are located two feet behind the wings and both the wings and tail surfaces serve to control the missile's flight.

Spanning about three feet, the wings have an aerodynamically smooth surface normally not equaled by conventional sheet-metal construction. Except for the plastic radome and wings, the missile is made of aluminum-alloy sheet.

After the missile is fired from the parent plane, a booster rocket takes over. When the Firebird reaches maximum speed, the spent booster is jettisoned by an explosive charge. During the latter phase of interception, power is supplied by the flight rockets. The warhead is designed to explode when it is close enough to an enemy plane to insure destruction. If the missile should miss the target, the warhead detonates in the air automatically.

Transcontinental Rocket Liner

REQUIREMENTS of a transcontinental rocket liner to cross the United States in less than an hour are within the grasp of present-day technology, Dr. Hsue-Shen Tsien, Robert H. Goddard Professor at the Daniel and Florence Guggenheim Jet Propulsion Center at California Institute of Technology, stated in a paper he presented before the annual meeting of the American Rocket Society, held in conjunction with the 1949 ASME Annual Meeting in New York, N. Y., recently. Dr. Tsien described the specifications for a liner capable of making a 3000-mile flight in less than sixty minutes.

In a 3000-mile flight, the liner would follow an initial elliptical path for 1200 miles, then glide for 1800 miles. Altitude at beginning of the glide would be 27 miles. Maximum velocity would be 9140 mph, but landing speed would be only 150 mph.

Such a rocket vehicle would weigh 50 tons at launching—of which 37 tons would be fuel load. It would be 80 ft long, and

have a maximum diameter of 9 ft. The wings would not need to be large to achieve a reasonable landing speed.

As a propellant, the rocket would use either a combination of liquid oxygen and liquid hydrogen, or liquid fluorine and liquid hydrogen.

One need not have any misgivings about high-energy fuels and propellants for cooling difficulties, he stated. Such strange combinations as liquid hydrogen and liquid fluorine, and diborane (B_2H_6) and liquid oxygen are to be considered.

With either film cooling or sweat cooling, there is no limit to the temperature of the combustion gas that can be effectively handled. He explained that film cooling is achieved by establishing a thin liquid film in contact with the hot gas over the surface to be cooled. Sweat-cooling, where the coolant is forced through the porous wall and injection and evaporation occur at the same time, is not limited to the liquid coolant. The coolant may be gaseous.

The short operating time of a rocket unit presents tremendous possibilities in design not feasible in turbojet and gas-turbine engineering.

By designing for minutes instead of for thousands of hours, as in the case of turbojets and gas turbines, we can use material stressed for ultimate strength, and not for creep, he said. It can be stressed six times higher than material intended for long operating time.

Problems in materials, thermochemistry, and chemical kinetics are among the questions to be investigated by the Daniel and Florence Guggenheim Jet Propulsion Center at California Institute of Technology, Dr. Tsien revealed.

The ultimate aim of all this basic research is of course to improve the performance of rocket and jet-propelled vehicles, Dr. Tsien stated.

He pointed out, however, that this is only one of the three functions of the Jet Propulsion Centers established in 1948 at CalTech and Princeton University by The Daniel and Florence Guggenheim Foundation. The Centers will also train leaders of the future in the field of rocket and jet-propulsion technology, and serve as centers of leadership in the development of peacetime commercial and scientific uses of rockets and jet propulsion.

D-558-2 Skyrocket

THE rocket-and-jet-powered research airplane D-558-2 Skyrocket has repeatedly exceeded the speed of sound in level flight it was announced recently by the Navy Department's Bureau of Aeronautics. Passage of this swept-winged exploratory craft into the supersonic has become routine and it is reported that the airplane and all its equipment function normally when flying through the critical speed range.

The Skyrocket is the second model of the national scientific research project known as D-558. Its predecessor, the Skystreak, has been obtaining flight data in the speed range up to the speed of sound. (See MECHANICAL ENGINEERING, October, 1947, page 852).

The Skyrocket was designed and built by the El Segundo Plant of the Douglas Aircraft Company Inc., El Segundo, Calif., with the co-operation of the National Advisory Committee for Aeronautics, for the U. S. Navy.

Some of the publishable technical details on the Skyrocket have been released in an article by E. H. Heinemann, chief engineer at Douglas, in which he discusses the design, power plants, structural arrangements, instrumentation, and the test program of the Skyrocket.

According to Mr. Heinemann, the use of the sweptback wing and tail is one method of increasing the upper speed limit by a substantial amount over the maximum speed of a straight wing. The airfoil sections are of the conventional subsonic type, with rounded leading edges and contours and not of the supersonic pointed type. The purpose of the Skyrocket is to explore the upper limits of this type of airfoil which permits retaining relatively normal low-speed characteristics. In short, it may be said that the Skyrocket is a highly complex, scientific instrument for the purpose of supplying aerodynamic data, not otherwise obtainable, that is necessary for the design of future aircraft.

The Skyrocket is equipped with a turbojet engine supplemented by a rocket power plant, making it capable of taking off, flying, and landing under its own power. The rocket motors are intended to be used primarily for high-speed test purposes They may also be used to shorten the take-off run.

The turbojet engine is a J-34, commonly known as a 24C, built by Westinghouse. The rocket motor is built by Reaction Motors, Inc. In the arrangement of power plants and fuel systems extreme care was taken to distribute all fuel uniformly about the airplane center of gravity to reduce trim changes to a minimum during fuel consumption. Exhaust outlets also were arranged carefully to react through the center of gravity in order to have minimum effect on airplane trim.

Tankage for 250 gal of aviation gasoline, not kerosene, is provided for the turbojet engine in addition to the special fuel carried for the rocket.

STRUCTURAL ARRANGEMENT

Magnesium alloy was used for the greater portion of the fuselage skin to good advantage. The wing and tail surfaces were made largely of 75S aluminum alloy.

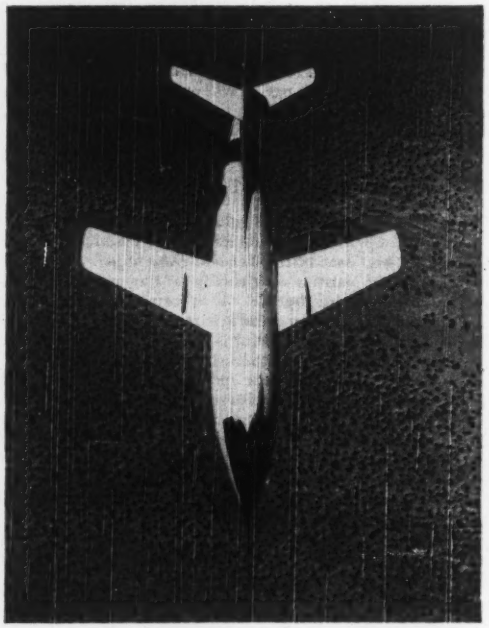


FIG. 2 THE SKYROCKET DURING ONE OF ITS 100 SUCCESSFUL FLIGHTS

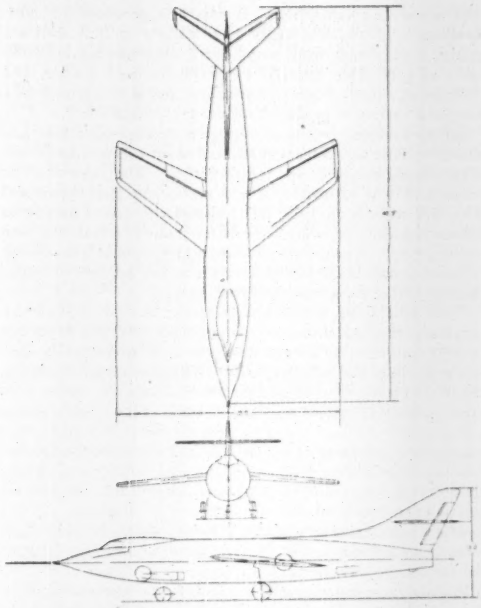


FIG. 3 THREE-VIEW DRAWING OF THE DOUGLAS D-558-2 SKYROCKET

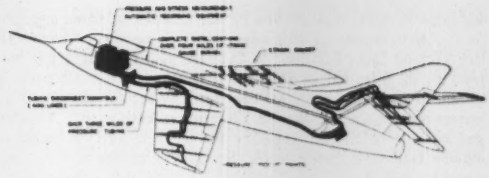


FIG. 4 INSTRUMENTATION DIAGRAM FOR THE SKYROCKET SHOWING STRESS-MEASURING STRAIN GAGES AND PRESSURE-MEASURING DEVICES

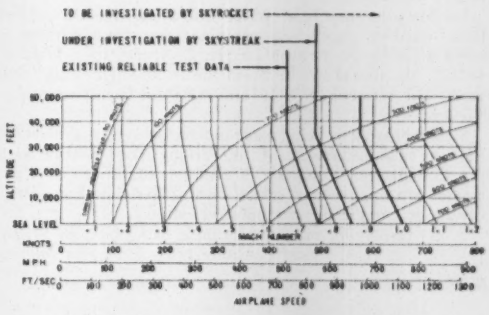


FIG. 5 CHART SHOWING SPEED AND ALTITUDE REGION FOR WHICH AERODYNAMIC CONDITIONS ARE PRESENTLY KNOWN, THE REGION BEING SURVEYED BY THE SKYSTREAK, AND THE REGION TO BE INVESTIGATED BY THE NEW SKYROCKET

To overcome the poor low-speed lift characteristics of the sweptback wings, Handley-Page leading-edge type automatic slots were provided.

Because of the wing sweep and insufficient space, it was found impracticable to house fuel and the landing gear in the wing. Accommodations for both in the fuselage therefore necessitated increasing the fuselage diameter considerably over that of the Skystreak.

Aerodynamic brakes are provided on the after portion of the fuselage for control of drag or speed.

The nose of the fuselage, containing the pilot's compartment, is jettisonable as a means of high-speed escape. The cockpit is pressurized and is equipped with refrigeration and heating equipment.

INSTRUMENTATION

Three types of recording instrumentation have been developed in addition to the pilot's normal flight instruments. A photographic flight recorder is used to record on motion-picture film the reading of a battery of flight instruments. A pressure-measuring system consisting of an automatically recording manometer may also be used to measure air pressure at 400 points on the wing and tail surfaces. Control forces and stresses in the structure are measured by means of 904 electric strain gages and automatically recorded by an oscillograph.

The air pressure and stress-measuring equipment are being used during the research phase of the project conducted by the NACA.

TEST PROGRAM

The test program will consist of the usual contractual demonstration flights conducted by the Douglas Company at the Air Force Test Center at Muroc Dry Lake, Calif., followed by an extensive research program at the NACA.

Although tests will be made at various altitudes and conditions of flight, a typical test run of the research program will be, for example, to take off with the turbojet and rockets in operation, climb to about 25,000 ft with turbojet alone, start the rocket motors, make the high-speed run, and return to the base with the turbojet. The whole operation takes only about thirty minutes. During the few minutes the rocket motor is operating one and one-half tons of rocket fuel are burned. The exact rate of consumption depends upon the method of firing of the rocket motors chosen by the pilot.

British Gas Turbines

THE first British gas turbine designed throughout as a prime mover for industry, was shown recently in London. The exhibit was a scale model of the prototype installed in the powerhouse of the works of Ruston and Hornsby Ltd., Lincoln, England.

The machine has been developed for general purposes and has a continuous full-power rating of more than 100 bhp. Its compressor delivers air through a heat exchanger to twin combustion chambers. The products of combustion are led to two separate turbines, the first of which drives the air compressor, while the second forms the power unit from which the drive is taken. Each of the main assemblies, such as the compressor, can be dismantled without interfering with the rest of the machine. Provision is made for protection against overspeed and failure of the lubricating system.

The rapid development of the gas-turbine-manufacturing

industry in Britain is shown by the number of firms engaged in the manufacture of this new source of power. Metropolitan-Vickers Ltd., London, W.C.2, are also making a gas turbine to be installed in their own factory. This company is about to complete a 15,000-kw stand-by set for the Stretford power station of the British Electricity Authority. Another gas turbine of similar capacity for the Authority's Dunston, Power Station is being made by C. A. Parsons & Co., Ltd. London, S.W.1.

C. A. Parsons is also constructing a 10,000-kw set for the National Gas Turbine Establishment at Pyestock, and this incorporates provision for district heating from the exhaust heat of the turbine.

London's Metropolitan Water Board has recently ordered three stand-by gas-turbine pumping sets. One of them is being made by the English Electric Company, Ltd., London, W.C.2; the second by the Brush Electrical Engineering Company, Ltd., London, S.W.1; and the third by Metropolitan-Vickers.

Steady progress is being made in developing gas turbines for blowing of blast furnaces. C. A. Parsons in co-operation with the Consett Iron Company is evolving the design of a gas turbine of this character, which eventually should find numerous applications in the iron and steel industry.

A gas turbine for rail locomotion is being built by Metropolitan-Vickers Electrical Company Ltd. It may be running early this year.

Building Materials

VARIOUS kinds of wallboards, fibrous insulation material, composition flooring, radiant heating, and a host of other new and unconventional products have been introduced into the building industry by materials manufacturers in order to make the modern house superior to anything the past has offered, an article in the *Industrial Bulletin* of Arthur D. Little, Inc., declares.

According to the *Bulletin* article, output of manufactured wallboards and related products in 1946 was four times the 1929 level, equivalent to one third the number of board feet of lumber used in construction; even this substantial production figure has since been exceeded.

Gypsum board, the most important of these products in terms of amount sold—3150 million sq ft in 1946—got its start in World War I. Three quarters of the production is used in homes. Made of gypsum plaster between sheets of slightly absorbent fibrous paper, the material is used as a lath base for plaster for interior walls or as a wallboard requiring no plaster. During World War II and most of the time since, wallboard has been the more important product, since it permits economical "dry wall" construction, an increasingly popular technique. An exterior gypsum sheathing board used during the war has since declined in importance, but a new type of "weatherproofing" may revive it. Both inside and outside, the use of large panels instead of individual boards saves construction labor.

Though long known, plywood has grown tenfold in use since 1925. Half the 1800 million sq ft used in 1948 went into new houses, for doors, wall panels, subflooring, and exterior sheathing, in both conventional and prefabricated houses. With waterproof synthetic-resin adhesives to permit use outdoors, one third of the total production in 1947 was of the exterior grade.

About 2000 million sq ft of structural insulation board is now used annually, 75 per cent of it in houses as interior paneling, roof insulation, and general building board. Made from wood and other fibers, it was first produced in 1914. Hardboard, of which roughly 1000 million sq ft is used annually, is also made from wood fibers, with the lignin of the wood as a bonding material to produce a hard, strong, and dense board, used as interior paneling and flooring, and as a base for a variety of products, such as prefinished tile.

Asbestos-cement products—shingles, corrugated sheets and boards of Portland cement reinforced with asbestos fiber—are tough, hard, fireproof, and weatherproof. The value of U. S. production was estimated at $50 million in 1946, compared with $10 million in 1929. The shingles are used mostly in houses and the sheets and boards for nonresidential and farm construction. A sandwich of fiber insulating board faced with asbestos-cement board is a relatively new product for residential exterior walls, partitions, and roof decks.

Home insulation, which has grown at least tenfold since a pneumatic method of insulating existing houses was developed in 1930, has probably done as much as anything for family comfort and it cuts fuel bills markedly. The commonest insulating material is mineral wool, made from rock, slag, or glass, with sales estimated at $30 million in 1947. New and growing materials are cotton-treated to prevent fire and mildew, and vermiculite, a mineral which unfolds into wormlike forms when heated. Vermiculite production rose from 22,000 tons in 1940 to 87,000 in 1946, with 60 per cent used in insulation and the rest as aggregate in plaster and lightweight concrete.

Also contributing to winter comfort is radiant heating, little more than a dream ten years ago, but now a reality in many developments and custom-built homes.

A glance at new construction reveals many other innovations. Concrete block is now common, with about 761 million blocks used in homes in 1949, and poured lightweight concrete is coming into use. Larger lighter brick and tile are in prospect. Aluminum in roofing, siding, and doors is common on farms, and is moving into the city. Glass is more generously used and, if the architects, who are now converted to modern design, succeed in influencing the merchant builders, use of glass in the future will be enormous.

Because changes in housing are accepted slowly, introduction of new materials requires decades rather than years, but there is evidence that the pace is quickening. Although prefabrication has been generally disappointing, 30,000 such homes were shipped in 1948.

Wear Measurement

MILLIONTHS of an inch can now be reproduced in a permanent, durable, and three-dimensional form by a method developed by the Bureau of Ships, Department of the Navy. The recording of hills and valleys on the surface of machine parts can be accomplished by this method in a few minutes' time with certain plastics that do not require the use of any weighing, measuring, heating, or pressurizing equipment. This was revealed by John W. Sawyer, Navy Department, Bureau of Ships, in a paper which he presented before a meeting of the Society of the Plastics Industry, Inc. in Washington, D. C., recently.

The recording of wear has been accomplished in the past by numerous procedures. Perhaps the three most common means are sketches, photographs, and impressions.

These methods of producing histories of wear have been generally satisfactory. However, they all fail to yield a relatively rigid three-dimensional reproduction that can be handled and explored with surface-measuring instruments such as the profilometer or Brush analyzer.

The new method developed by the Bureau of Ships for re-

cording surface finish and wear patterns utilizes a free-flowing polyester resin. This resin hardens in ten to twenty minutes, after the addition of a catalyst, without application of external heat or pressure. The impression is formed by casting the resin-catalyst mixture on the surface to be recorded. The casting may be removed for study after cooling.

The plastic, a polyester resin, is obtainable in preweighed quantities. It is packaged in either a two- or three-component container. The two-component kit contains resin in one unit, with filler added, and catalyst in the other compartment. There has been some uncertainty as to the shelf life of this two-conponent material. A three-component kit with resin, filler, and catalyst in separate sections is available. It is believed the relatively short shelf life of the two-unit mix may be due to a reaction between the filler and resin. The three-element container may increase shelf life of the materials from three months to twelve months.

The two-component mix is prepared for casting by thoroughly stirring the catalyst with the resin. The resin and filler should be well mixed prior to addition of the catalyst. In the case of the three-component package the filler is mixed with resin and then the catalyst is added.

Restriction of the plastic to a desired area may be accomplished by a number of devices. Dams of paper, molding clay, putty, and other materials may be utilized as the occasion requires. The most versatile material for this purpose appears to be Scotch tape. It is simple to apply, effective in sealing, easy to remove, and has no apparent effects on the resulting impression.

The procedure for producing a plastic negative replica of a metal surface is simple. Use of elaborate equipment and strict adherence to minute details are not required. There are, however, simple routine steps that should be followed to give the most accurate reproductions. It is essential that the metal surfaces be free of foreign materials such as oil, grease, scale, water, and other matter that would result in poor reproductions or cause sticking of the resin to the surface.

Experience with this method has shown it to be entirely satisfactory for use in indicating general wear patterns and recording with extreme accuracy surface finishes. Negative replicas of gear teeth have provided histories of changing wear during test periods. Surface finishes of machine elements have been reproduced, in the negative, with accuracy. Profilometer measurements of a surface-roughness comparator plate and of a plastic impression of this plate indicated a variation in surface finish, microinches root mean square, of 0.9 in the range 2.9 to 17.4, and a variation of 4.0 from 33.0 to 70.3.

The Bureau of Ships has to date utilized this method for recording surface conditions of reduction-gear teeth during test and normal operation. The ease with which these records can be produced would seem to assure a wide range of applications for this resin.

Radioactive-Waste Disposal

THE laboratory and production operations of the United States atomic-energy program create a variety of potentially harmful waste materials which must be handled in special ways. The problem of waste disposal is not unique to the atomic-energy industry. Many other large industries must dispose of noxious waste materials created in the course of their operations. In this respect, the atomic-energy industry differs from other industries in that many of its wastes before treatment involve relatively large amounts of radioactivity, with which public-health officers, sanitary engineers, and others concerned with waste disposal have had little experience in the past.

Since improper handling of radioactive waste materials could endanger public health, the United States Atomic Energy Commission believes that the facts about this problem should be available.

The Atomic Energy Commission, therefore, has recently compiled and issued a nontechnical report on the safe handling of radioactive wastes in the atomic-energy program.

The report describes radioactivity and its biological effects, the types and sources of radioactive wastes in the atomic-energy program, and the methods used for safe handling of wastes and protecting workers and the public from radioactive contamination.

The report also gives details about the extensive research program currently supported by the AEC to improve waste handling and storage methods. As better methods are devised, they are put into routine operation at atomic-energy plants, often bringing about considerable savings in the cost of waste control.

For example, recent improvements in processing wastes from chemical separations plants have reduced by 20 per cent the volume of liquid wastes which must be stored. It is expected that the amount will be reduced to 50 per cent in the near future, which will result in saving about a million dollars a year.

The report points out that gaseous, liquid, and solid wastes appear at each of the various radioactive or "hot" steps in atomic-energy processes. The methods of safe handling used to date have successfully protected workers and the public.

The ultimate goal of AEC's present research program is to improve the basic design of equipment to cut down waste at the source, rather than to attempt to deal with it by such means as filters and retention basins after it has have been produced.

In carrying on its program for safe handling of radioactive wastes, the AEC relies heavily upon the individual programs of its prime contractors. In addition, it draws upon the talents and knowledge of other Federal agencies, of state and local health officials, and sanitary engineers, and of specialized industrial consultants trained in engineering and health techniques.

The report entitled, "Handling Radioactive Wastes in the Atomic Energy Program," may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 15 cents per copy.

Solar-Energy Heating

THE basic principles of space heating with solar energy have been established and the trend of development is clearly indicated, it is revealed in an article by Maria Telkes, in *The Scientific Monthly*, December, 1949. However, considerable research and development work are probably still needed before solar space heaters will be readily available for general use.

According to the article, space heating consumes nearly 30 per cent of the fuel used in the United States. The yearly value of this fuel has been estimated at 3500 million dollars. In other parts of the world an even greater percentage of the fuel produced is burned to maintain comfortable temperatures.

For the purpose of evaluating the possibilities of solar space heating, consider a small home, receiving 1000-1500 Btu per sq ft of solar energy during an average winter day, with a heat load of 400,000 Btu per day, corresponding to conditions of 1000 deg-days per month. These are typical conditions for latitude 35° to 40° in the United States. If it were possible to use for space heating at least 50 per cent of the average winter solar energy—that is, 500-750 Btu per sq ft during an average

winter day—this small home would require a solar-energy collecting surface of 500–800 sq ft. Such a surface cannot be regarded as excessive, and it may easily be incorporated in the roof or south wall of the house. In warmer locations the solar-energy collecting area could be correspondingly smaller.

During the past twenty years solar water heaters have become increasingly popular in Florida and California. In these states clear weather occurs nearly 70 per cent of the possible time, and a cloudy day is seldom followed by another cloudy day. The water heaters consist of a collector of solar energy, mounted on the roof, and an insulated storage tank large enough to store at least two days' supply of hot water. The collector is a well-insulated flat box, covered with one or two air-spaced glass panes, to transmit solar energy, which in turn is absorbed by thin black metal plate with water circulating pipes soldered to it. According to various reports, the efficiency of such heaters is rather high in Florida and California. If properly designed, the solar heaters can convert at least 50 per cent of the incident solar energy for the purpose of heating water. The most difficult problem is the need for storing enough hot water for the inevitable cloudy days.

Experiments incorporating a large water heater in the roof of a test structure have been conducted at the Massachusetts Institute of Technology in Cambridge, Mass., since 1940. It was found that the two-room structure could be heated during the winter, but that this required an excessively large storage tank. Similar experiments are now in progress in a small home located near the Institute, using a roof-type water heater with a storage tank capable of accumulating a two days' supply of heat, with additional electrical heating provided for the inevitable sequences of cloudy days. Other tests have been carried out in Switzerland.

In Colorado another home used crushed rocks as the heat-storage medium. Solar heat was collected on the roof, behind air-spaced glass panes, and the warm air was circulated through the house, or through an insulated compartment filled with heat-storing rocks. This house used a conventional fuel-burning furnace because solar heat could be stored only overnight.

South-facing windows transmit considerable amounts of the low-slanting rays of the winter sun, and the use of such large south-facing windows has recently become popular. These architectural "solar houses" may collect a great deal of solar heat during clear winter days, often overheating the house. The gain is rapidly lost at night and on cloudy days, and consequently a true "net gain" is probably limited to warmer climates.

The need for storing solar heat, not only overnight, but also during a sequence of cloudy days, is obviously a critical problem. If the collector temperature is limited to a 110 F maximum for reasons of collection efficiency, the temperature of heat storage must be lower. For space heating, an average indoor temperature of 70 F is required, and therefore the temperature of heat storage must be greater than this value; consequently, the temperature change of the heat-storage medium will be limited to a rather narrow range, possibly not more than 20 F.

Using the specific heat of water for heat-storage purposes, it is probable that not more than 20 Btu can be stored effectively per pound of water during one winter day. The specific heat of other materials (rocks, etc.) is lower than that of water, and their heat-storage capacity per pound will be lower, too.

Fortunately, the specific-heat effect is not the only heat-storage possibility. The heat of transformation, or heat of fusion of chemical compounds, appears to offer much higher heat capacity for storage. Several chemical compounds, or mixtures, are available, with heat-storage capacities in excess

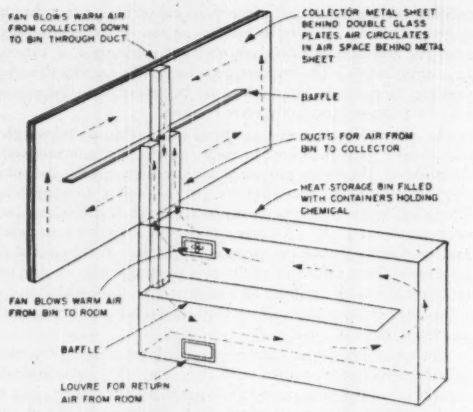

FAN BLOWS WARM AIR FROM COLLECTOR DOWN TO BIN THROUGH DUCT
COLLECTOR METAL SHEET BEHIND DOUBLE GLASS PLATES AIR CIRCULATES IN AIR SPACE BEHIND METAL SHEET
BAFFLE
DUCTS FOR AIR FROM BIN TO COLLECTOR
HEAT STORAGE BIN FILLED WITH CONTAINERS HOLDING CHEMICAL
FAN BLOWS WARM AIR FROM BIN TO ROOM
BAFFLE
LOUVRE FOR RETURN AIR FROM ROOM

FIG. 6 HEATING SYSTEM BASED ON HEAT-OF-FUSION PRINCIPLE FOR SOLAR-HEAT STORAGE

of 100 Btu per pound of material. Some of these compounds melt within the 90 to 100 F temperature range and are readily available at low cost. Typical materials are sodium sulphate decahydrate, melting at 90 F, or disodium phosphate dodecahydrate, melting at around 95 F. There are several other suitable mixtures.

The amount of heat required to melt these compounds is stored in them; when the heat is abstracted, the materials recrystallize. The process of fusion and resolidification can be repeated continuously. The chemical compound is placed in closed containers, and it never needs to be renewed. Some of these materials are capable of storing eight to ten times more heat than is possible with water when equal volumes are compared. The use of these heat-of-fusion materials, therefore, diminishes the heat-storage volume required for space heating with solar energy. Fig. 6 shows one of the possible solutions of arranging a solar-energy collector and the heat-storage material, assembled in a "heat bin."

In December, 1948, an experimental house located in Dover, Mass. (15 miles from Boston), was completed. The house uses the heat-of-fusion principle for solar-heat storage. The south-facing vertical collector of the 720-sq-ft area is located in the attic of the house. Air warmed by solar energy is circulated by fans to the heat-storage units, heat bins located between the rooms.

The total volume of the chemical mixture used is 470 cu ft (3500 gal), and its weight is 21 tons, capable of storing about 4 million Btu at 88 to 90 F. The house has a volume of 10,000 cu ft, and the average winter heating requirement is 400,000 Btu per day; therefore the completely charged heat bins should be capable of providing space heating for ten consecutive sunless winter days.

The heat is transferred from the storage units into the rooms partly by radiation through the walls of the bins and partly by circulating the air of the rooms through the bins. It is obvious that several other locations for the collector and the storage units are equally possible, as well as other systems of heat transfer.

Preliminary data, collected last February, indicate that the collection efficiency during the entire month was 41 per cent of the total incident solar energy. During this month there were ten days when no heat could be collected at all. The total amount of solar energy recorded during these ten cloudy

days was less than the amount received during an average clear day. The collection ranged in efficiency from 45 to 60 per cent during clear days, but it was lower on partly cloudy days. The longest sequence of cloudy days was five, which is in accordance with weather statistics in this vicinity.

During the summer the ducts of the collector are opened, and the cool night air is circulated through the storage system, lowering its temperature. The specific-heat capacity of the solidified chemical compound is sufficient to keep the house comfortably cool during the warm summer days. In this way the winter storage system can be operated in reverse during the summer.

The use of solar space heating offers numerous advantages, the article concludes. The relatively low temperatures encountered during its operation preclude any fire hazards. There are no problems due to smoke, ashes, and their disposal, and the fuel it saves can be used for other purposes. After the initial cost of installation, the upkeep of the solar heater is very low. Solar space heating should be an important economic factor in regions where coal is scarce or where it has to be imported.

Gas-Turbine Self-Starter

THE first fully automatic "self-starter" for a gas turbine in central-station service has been completed by the Switchgear Division of the General Electric Company. The equipment, which is said to perform, automatically and in sequence, the starting and stopping operations, will be put in service by the Central Maine Power Company at the Farmingdale Station.

A 3500-kw gas turbine, fueled by Bunker C oil, will be put through its normal starting and stopping sequence by the equipment. The following functions will be automatically performed by the unit in properly timed sequence in starting:

1 Energizes the turning gear to "break away" the unit.
2 Starts the cranking motor to bring the unit up to partial speed and actuate the air compressor.
3 Opens the fuel valve.
4 Ignites the fuel.
5 Allows the unit to accelerate under its own power.
6 Transfers the fuel supply from starting Diesel fuel to Bunker C for running.

After reaching normal speed the unit is controlled by the operator in the same manner as a steam turbine to synchronize the generator with the bus.

The stopping functions are automatically performed in the following sequence:

1 Fuel supply transferred back to Diesel fuel to purge the fuel lines of Bunker C oil.
2 Fuel supply is gradually reduced until the flame goes out.
3 Unit coasts to a standstill.

While provision is made for annual testing of the individual steps, the starting and stopping sequence is always automatic.

Protective features are included to provide emergency shutdown in case of abnormal temperatures, fuel, and air pressure.

Plating-Thickness Meter

MORE uniformly coated electrolytic tin plate is reported to be obtained by using a new instrument developed at the Research Laboratory of Carnegie-Illinois Steel Corporation. This meter, which continuously indicates and records tin coating thickness on steel strip during the plating operation, is now in regular use on all "Ferrostan" electrolytic-tinning lines of United States Steel.

The new coating-thickness meter operates entirely independently of other control instruments on the lines. Its function is to combine the electrical values of plating current, strip speed, strip width, and plating efficiency in a precision circuit employing a self-balancing potentiometer to indicate and record thickness. For the convenience of the operator the instrument is calibrated in pounds per base box. See Fig. 7.

Formerly, the weight of coating was tested by chemical means from sample sheets selected at intervals from the lines.

Now, when changing from one ordered thickness of coating to another, the operator is not required to read a battery of meters and refer the readings to a chart. Instead, he adjusts the plating control dials until the plating-thickness meter indicates the specific coating weight. Since the instrument provides a continuous indication of coating weight, any variation in plating thickness is indicated at once.

Provision can be made for the instrument to operate an alarm when the coating weight deviates from the specified value. Also, if desired, the equipment may be set readily to control coating weight.

Reference potentials which actuate the meter are received from a tachometer generator, whose electrical output is directly proportional to the strip speed, and from a shunt or the equivalent in the plating-current bus, which provides a potential directly proportional to the total plating current. Thus potentials that are always proportional to strip speed and total plating current are supplied to the meter continuously.

Since the quantity of tin deposited per unit area on the strip is a function of plating-current density, plating time, and the efficiency of the plating bath, provisions were made to compensate for variations in these factors. The strip-width compensating potentiometer is calibrated to cover material 18 to 34 in. wide. The strip-width adjusting dial (lower right in Fig. 7) is calibrated in inches and can be set readily within plus or minus $\frac{1}{16}$ in.

FIG. 7 PLATING-THICKNESS METER

Another potentiometer compensates for plating efficiency variations. Its indicating dial (lower left in Fig. 7) is calibrated in per cent and covers a range of 84 to 100 per cent plating efficiency.

The potentiometers and all resistors are contained in a steel cabinet mounted above and attached to the plating-thickness meter.

Following installation and calibration of the original plating-thickness meter approximately 80 tests were made over a 10-day period of normal operation. These tests covered electrolytic tin-plate production ranging from 0.25 to 0.75 lb per base box. In each test chemical determinations of coating weight were compared with indications on the plating-thickness meter. The meter was found to indicate coating weights as accurately as the chemical method.

Use of the meter is said to permit more accurate maintenance of plating conditions, thereby preventing excess plating of certain products and assuring against coating deficiencies in others.

Atomic-Energy Progress

RECENT progress in the Atomic Energy Commission's various programs has been released and while some of the phases have been mentioned in these pages periodically, the following general roundup of latest information on atomic developments should be of interest.

Accelerator Program

Particle accelerators or atom smashers are among the most important tools in nuclear research. The 184-in. cyclotron at the AEC's Radiation Laboratory, Berkeley, is at present the greatest of these machines. However, two Commission-financed machines now being designed and under construction will dwarf this huge machine.

At Brookhaven National Laboratory scientists are building a proton synchrotron (the Cosmotron) which will impart energies of from 2 to 3 billion electron volts to subatomic particles. Scientists are running model tests of the huge magnets for this machine. The building excavations are complete and the foundations have been poured for more than a year to permit adequate settling before the huge superstructure is added. Equipment has been on order for many months and is now being received.

A still greater machine—the Bevatron—is being built at the Berkeley Radiation Laboratory. A quarter-scale model of this enormous machine was built in record time to test the feasibility of the full-scale machine. Tests of the model have proved that the great machine will operate as planned and construction is being rapidly pushed. Steel for the 10,000-ton ring-shaped magnet is being shipped and the machine is expected to be ready for preliminary testing by the middle of this year.

Reactor Development

Unforeseen technical difficulties in design, engineering, and construction have delayed completion of the 30,000-kw nuclear reactor at Brookhaven. The new research reactor originally scheduled for completion during the fall of 1949 is now not expected to start operation for several months.

The major difficulties developed during testing of a new-type air-cooling system under simulated operating conditions. The tests revealed that the air-duct work of the system as originally designed would not stand up under operating conditions, and important modifications in the design and construction of the cooling system are being made.

While alterations are being made on the cooling system, design and construction of other features of the pile, now 90 per cent complete, are also being rechecked.

Testing of reactor components and construction both before and after installation is extremely rigid. It is necessary to take out all the "bugs" before operation begins. To make alterations or repairs after the reactor begins to operate is extremely difficult and in some cases impossible.

The Brookhaven reactor is designed for use for research purposes, and is similar in type to the research reactor in operation at Oak Ridge National Laboratory. Both reactors operate with slow neutrons using natural uranium as fuel with a graphite moderator to slow down the neutrons.

The status of work on the four reactors currently composing the Commission's reactor-development program is as follows:

The nuclear design of the experimental breeder reactor has been completed by the Argonne National Laboratory at Chicago, Ill., and detailed architect-engineering design work is more than 90 per cent complete. The architect-engineer for the reactor structure is the Austin Company of Cleveland, Ohio. Installation of utilities, excavation work, and construction of an access road is under way.

The Bechtel Corporation of San Francisco, Calif., will build the steel, brick, and concrete reactor structure, as well as the control, ventilation, cooling, and other auxiliary equipment. The reactor core—heart of the nuclear machine—will be furnished by the Argonne National Laboratory, where it is being designed and built.

The experimental breeder reactor is designed to test the practical feasibility of breeding with fast neutrons and to investigate the application of liquid metals to the removal of fission-produced heat from reactors at high temperatures. Originally planned for erection at the DuPage County, Ill., site of the Argonne National Laboratory, the reactor will be built at the new Nuclear Reactor Testing Station near Arco, Idaho, so that it may be operated at a higher power level than would be feasible in a populated area. This will increase the usefulness of the reactor as a research tool by making possible greater flexibility in design and operation. Although the reactor is not designed for the purpose of producing useful power, an incidental amount of power may be produced as a by-product.

The breeder reactor will differ from the fast reactor now in operation at Los Alamos in the design of fuel elements and type of coolant used to extract the energy. Furthermore, it will operate at a very much higher power level. Total cost is expected to be about $3,500,000.

The scientific design of the materials-testing reactor has been developed in a co-operative effort by the Oak Ridge National Laboratory and the Argonne National Laboratory. A $1,870,000 contract for detailed engineering design work on the reactor was signed last September with the Blaw-Knox Construction Company of Pittsburgh, Pa. Design work is under way and construction is expected to begin by next spring.

The primary purpose of the materials-testing reactor will be to test under conditions of severe neutral bombardment the materials which may be used in future reactor construction. The materials to be tested will be contained in test pockets. The neutron bombardment to which they will be subjected will be of an intensity very much greater than any ever experienced before. Since the power reactors of the future will be operated at greater neutron intensities than those in operation today, it is important to learn in advance how various materials that might be used in the structures, cooling systems, or shields will react under these unusual conditions.

The materials-testing reactor is of particular interest in the

development of reactors for the propulsion of aircraft, since it points in the direction of compact high-radiation-density reactors which must ultimately be developed if aircraft are ever to be propelled by atomic energy. On the basis of rough preliminary estimates, it is expected that the reactor will cost about $25,000,000.

The Argonne National Laboratory and the Westinghouse Electric Corporation are engaged in the development of a land-based prototype of a reactor suitable for ship propulsion. Although this reactor, like the experimental breeder reactor and the materials-testing reactor, will be built at the Nuclear Reactor Testing Station in Idaho, the engineering and development work is being carried out at Argonne and in the new laboratory of the Westinghouse Atomic Power Division on the site of the old Bettis Airport near Pittsburgh. Construction of the new laboratory was begun in July, 1949, and is scheduled for completion by this summer. Present obligations under the Westinghouse contract are approximately $6,000,000, of which about $2,600,000 is for operating costs and $3,400,000 for capital construction costs and equipment.

Research and development work is well advanced, and detailed engineering design of the ship-propulsion reactor is scheduled to begin in about a year. Construction should be under way by 1952. Although cost estimates cannot be made until detailed design specifications have been completed, it is expected that the reactor will cost at least $25,000,000, and perhaps substantially more, depending upon the solutions found possible for the technical problems encountered.

The ship-propulsion reactor will be a single-purpose machine designed specifically for the purpose of producing large amounts of heat under conditions that will permit conversion to power for propulsion of naval vessels.

Engineering design work on the intermediate power-breeder reactor, planned for construction at the West Milton, N. Y., site of the Knolls Atomic Power Laboratory near Schenectady, is being carried forward to permit a firm estimate of construction costs to be made. Preliminary site work, now under way, is expected to be completed in time for construction of major facilities to begin as early as possible in the 1950 construction season.

The Knolls reactor is designed to produce significant amounts of electric power utilizing neutrons in the intermediate energy range, and to investigate the possibilities of breeding fissionable material at the same time. If successful in both, this reactor would represent a major step forward in the direction of the production of useful power without depleting—and perhaps even increasing—the national supply of fissionable material. To date, no reactor has been built to operate in the intermediate energy range. Like the experimental breeder reactor, the heat energy of the intermediate reactor will be removed by means of liquid metal. This heat will then be used to generate power through conventional means. The Knolls reactor is expected to have an eventual cost of from $25,000,000 to probably as much as $40,000,000, depending upon the technical problems encountered.

Gaseous-Diffusion Plant

With construction well under way on K-29, the third in a series of gaseous-diffusion units for production of Uranium-235 in the Oak Ridge area, the Atomic Energy Commission announced that the Maxon Construction Company, Inc., Dayton, Ohio, had been approved as construction contractor and Giffels & Vallet, Inc., of Detroit, Mich., as architect-engineer for the building of a fourth gaseous-diffusion unit, K-31, which will cost approximately $162,000,000.

The Maxon Company and Giffels & Vallet already are engaged in the building of K-29, a $66,000,000 project. The Carbide and Carbon Chemicals Corporation, operator of the present gaseous-diffusion units, K-25 and K-27, is responsible for process development and process design for both K-29 and K-31 and for procurement of special production equipment and materials.

The Commission said that preliminary design work already has been accomplished, and preliminary construction work begun on K-31. As continuations of the gaseous-diffusion process and with the same general design, both K-29 and K-31 will contribute to increased production of Uranium-235.

Production

A new plutonium metal-fabrication plant began operations at Hanford in July, 1949.

Construction was started in August on a $67,000,000 expansion of the U-235 production plant at Oak Ridge. Under the new expansion program an additional $185,000,000 will be spent at Oak Ridge to increase production capacity. Work will start on the major plant addition under the new expansion program in January, 1950; design work already has been well started.

Radioisotopes

Radioisotopes, called the most useful research tool for biology and medicine since the discovery of the microscope, are distributed from Oak Ridge at the rate of 400 shipments per month to laboratories all over the United States and to 22 foreign countries. Less dramatic perhaps but equally revolutionary is the application of radioactive tracers to physics and chemistry, industrial processing, metallurgy, and agriculture.

For example, radioisotopes are more and more useful to American industrial processing. A number of recent shipments brings this out. The U. S. Testing Co., Hoboken, N. J., one of the oldest commercial testing laboratories in the country, is using radiocobalt (cobalt 60) to make comparative tests of wearing characteristics of floor wax.

The B. F. Goodrich Research Center, Brecksville, Ohio, is attempting to use radiophosphorus (phosphorus 32) to trace leaks in the cooling-water line of an air-conditioning system. The water-glycol mixture in the supposedly closed cooling system was found to be leaking into process water. Despite the large dilution by process water it is believed that radiophosphorus will still indicate some of the leak.

Science Abstracting

SINCE the International Conference on Science Abstracting, held under the auspices of UNESCO, in Paris, June 20–25, 1949, the representatives of nine engineering societies of nine countries, at a meeting in London, set up a working party of four members on engineering abstracting, one each being nominated by England, Holland, France, and the U. S. A. The individual representatives are W. K. Brasher, H. Sangster, P. Lecomte, and C. E. Davies.

At the UNESCO Conference it was recommended that a standard guide for the preparation of synopses be provided for the use of editors and authors. The "Guide for the Preparation of Synopses," prepared by the Abstracting Services Consultative Committee and issued by the Royal Society, Burlington House, London, W. 1, was suggested as a basis for discussion.

This guide, as prepared by the Royal Society, contains excellent information on the purpose, style, content, and layout

of an abstract and should be of value to ASME authors and other writers as well. The guide follows:

1 *Purpose.* It is desirable that each paper be accompanied by a synopsis preferably appearing at the beginning. This synopsis is not part of the paper: It is intended to convey briefly the content of the paper, to draw attention to all new information and to the main conclusions. It should be factual.

2 *Style of Writing.* The synopsis should be written concisely and in normal rather than abbreviated English. It is preferable to use the third person. Where possible use standard rather than proprietary terms, and avoid unnecessary contracting.

It should be presumed that the reader has some knowledge of the subject but has not read the paper. The synopsis should therefore be intelligible in itself without reference to the paper; for example, it should not cite sections or illustrations by their numerical references in the text.

3 *Content.* The title of the paper is usually read as part of the synopsis. The opening sentence should be framed accordingly and repetition of the title avoided. If the title is insufficiently comprehensive the opening should indicate the subjects covered. Usually the beginning of a synopsis should state the objective of the investigation.

It is sometimes valuable to indicate the treatment of the subject by such words as: brief, exhaustive, theoretical, etc.

The synopsis should indicate newly observed facts, conclusions of an experiment or argument and, if possible, the essential parts of any new theory, treatment, apparatus, technique, etc.

It should contain the names of any new compound, mineral species, and any new numerical data, such as physical constants; if this is not possible it should draw attention to them. It is important to refer to new items and observations, even though some are incidental to the main purpose of the paper; such information may otherwise be hidden though it is often very useful.

When giving experimental results the synopsis should indicate the methods used; for new methods the basic principle, range of operation, and degree of accuracy should be given.

4 *Detail of Layout.* It is impossible to recommend a standard length for a synopsis. It should, however, be concise and should not normally exceed 200 words.

If it is necessary to refer to earlier work in the summary, the reference should always be given in the same manner as in the text. Otherwise references should be left out.

When a synopsis is completed, the author is urged to revise it carefully, removing redundant words, clarifying obscurities, and rectifying errors in copying from the paper. Particular attention should be paid by him to scientific and proper names, numerical data, and chemical and mathematical formulas.

Gas-Turbine-Disk Tester

A PRECISION testing machine has been designed in order to carry out a part of a research project to determine the strength of gas-turbine disks, and is described in scientific paper No. 1461, by A. C. Hagg, B. Cametti, and G. O. Sankey of the Westinghouse Research Laboratories, East Pittsburgh, Pa. The experimental studies in parallel with theoretical studies have as their objective the development and evaluation of disk design calculation methods.

The machine can handle disk specimens up to 14 in. in diam and 2 in. thick, and larger specimens can be handled with only minor modifications. The specimen is mounted with the axis vertical on a flexible shaft; an induction-motor drive covers a speed range up to 35,000 rpm. The furnace is designed for a specimen temperature up to 1500 F. The specimen temperature may be uniform or arranged for radial gradients up to about 100 F per in.

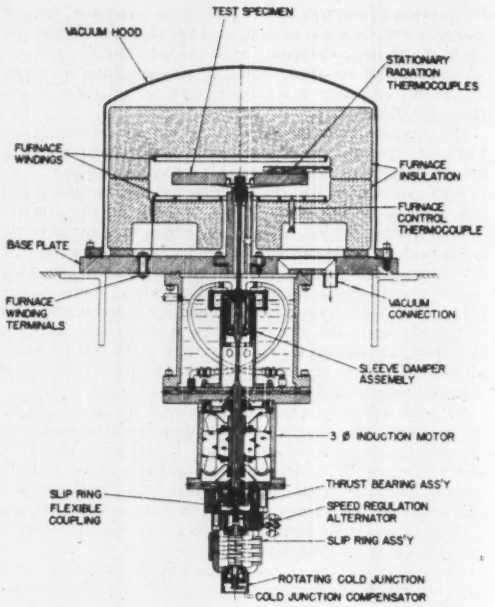


FIG. 8 CROSS SECTION OF HIGH-SPEED DISK TESTER

Primary design emphasis was placed on means for accurate measurement and control of specimen speed and temperature, and on the determination of plastic and creep strains. Average speed error for a run is less than 0.01 per cent; the maximum instantaneous error is about 0.5 per cent. Specimen temperature is continuously measured and recorded using specially developed thermocouple circuits and slip-ring coupling; temperature errors are less than 10 F by test calibrations. Plastic and creep strains are measured over the disk surfaces in radial and tangential directions utilizing punch-marked spacings. The average error in strain measurement is 5 per cent.

The testing machine has been operated for a total period of about 100 hr. During this period there has been only one mechanical difficulty, namely, breakage of thermocouple wire (alumel) at the disk. These failures were finally traced to a carburization of the alumel wire due to excessive oil vapor in the furnace volume, which in turn was caused by improper oil drainage from the damper chamber. Large oil drains and improvements in the vacuum pumping circuit eliminated this trouble. The rotating system, the auxiliaries, and controls have given trouble-free service from the start.

The time required to carry out a test exclusive of the actual running time is approximately 150 man-hours; this corresponds to two men working a two-week period. During a test run, present practice is to have an operator in attendance; although the operator is for the most part free to carry out other parts of the testing sequence such as strain measurements on previous or succeeding test disks.

Some initial test results included in the paper illustrate the type of data that can be obtained.

ASME TECHNICAL DIGEST

Substance in Brief of Papers Presented at ASME Meetings

Boiler Feedwater Studies

Chemical Treatment, Demineralization, or Evaporation for Make-Up in High-Pressure By-Product Steam Plants, by J. D. Yoder, Mem. ASME, The Permutit Company, W. L. Webb, and T. Baumeister, Mem. ASME, American Gas and Electric Service Corporation, New York, N. Y. 1949 ASME Annual Meeting paper No. 49—A-71 (in type; to be published in Trans. ASME).

Power manufactured as a by-product of process steam offers the lowest cost for fuel in mills per kwhr obtainable from any type of power plant. The most efficient high-pressure power plant which is devoid of the by-product feature and which delivers only one product—kwhr as electric energy—still wastes, as low-grade heat in cooling water of the condenser system, approximately 50 per cent of the heat supplied in fuel.

The utilization of exhaust steam for process makes possible the avoidance of the heat loss to the cooling water. This is accomplished by using (1) high-pressure turbines exhausting to evaporator coils, which in turn deliver process steam at some practical lower pressure, or (2) high-pressure turbines exhausting directly to the process headers. Either method avoids the Btu loss to the condenser cooling water.

This paper emphasizes the greater amount of low-heat-rate by-product which can be generated when turbines are exhausted directly to process rather than to evaporator coils; presents operating data for a 1400-psi plant to substantiate these conclusions, and demonstrates the satisfactory chemical treatment of water for these conditions.

The great advantage of exhausting turbines directly to process instead of to evaporator coils is the greater amount of low-fuel-cost power that can be produced.

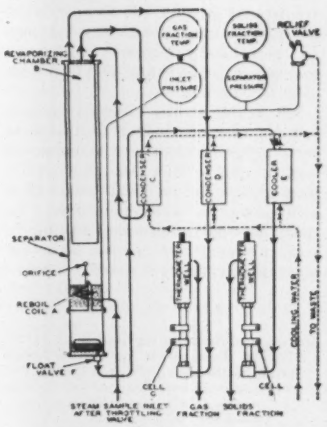
The power, when using evaporators at a constant vapor pressure, increases as the differential in pressure between evaporator coils and process steam diminishes, or as the mean temperature difference across the evaporator surface is decreased. The amount of heating surface needed in the evaporator coils increases as the pressure or temperature differential becomes less, which correspondingly increases the cost of evaporators.

An Automatic Degasser for Steam Sampling in Power Plants, by H. M. Rivers, W. H. Trautman, Hall Laboratories, Inc., Pittsburgh, Pa., and G. W. Gibble, Arabian-American Oil Company, Ras Tanura, Saudi, Arabia. 1949 ASME Annual Meeting paper No. 49—A-74 (in type; to be published in Trans. ASME).

A new degasser has been developed which automatically splits a steam sample into two approximately equal streams of condensate, one containing all solid impurities, the other containing all gaseous impurities in the original sample. Heat-exchange elements are combined in a unique way which guarantees that the weight ratio of one stream to the other will remain substantially constant. Both streams pass through conductivity flow cells so the degree of contamination can be measured continuously by conductometric means.

The new degasser has the following features:

Under normal operating conditions substantially all ionizable gases are removed from the solids fraction. Even



SCHEMATIC DIAGRAM OF DEGASSER

How to Order ASME Papers

PAMPHLET copies of ASME papers referred to in this section are available, until the supply is exhausted, at 25 cents each to members; at 50 cents each to nonmembers. ASME papers published in full or condensed form in other sections of MECHANICAL ENGINEERING are not included in this Digest Section.

To facilitate ordering papers, coupon books, each containing ten coupons, are available to members at $2 each, to nonmembers at $4 each.

Coupons may be used to purchase papers presented at ASME Meetings. When ordering, please give number assigned to article, title, author's name, and number of copies wanted. Orders should be sent to the ASME Order Department, 29 W. 39th St., New York 18, N. Y.; or, use convenient order form below.

NOTE: ASME Publications and advance copies of ASME papers are on file in the Engineering Societies Library and are indexed by the Engineering Index, Inc., both at 29 West 39th St., New York, N. Y. ASME Transactions and *Journal of Applied Mechanics* are also on file in ASME depositories maintained in 245 libraries in the United States, including libraries of all ASME Student Branch institutions.

ASME Order Department
29 W. 39th St., New York 18, N. Y.

Date.....

Please send me the papers indicated by the following circled numbers:

49—A-62,	49—A-85,	49—A-120,
49—A-63,	49—A-98,	49—A-121,
49—A-64,	49—A-99,	49—A-122,
49—A-65,	49—A-100,	49—A-124,
49—A-66,	49—A-109,	49—A-125,
49—A-67,	49—A-112,	49—A-128,
49—A-71,	49—A-113,	49—A-129,
49—A-74,	49—A-114,	49—A-130,
49—A-75,	49—A-115,	49—A-136
49—A-76,	49—A-119,	

Name.....

Address.....

☐Remittance enclosed ☐Bill me

☐ASME Mem. ☐Nonmem.

in extreme cases 95 per cent or more are removed.

Because of the inherently stable thermodynamic cycle employed, operation is automatic and cannot be affected materially by even abnormal changes in boiler operation.

Since steam and condensate flowing to the cells contact only stainless steel, minimum pickup of contaminants is assured.

The time interval from entrance of steam into the degasser to the passage of degassed condensate out of the conductivity flow cell for the solids fraction is of the order of 1 min. The averaging effect of holdup in blunting or spreading out over a period of time momentary conductivity changes is avoided.

Since the lag is small, conductivity-recorder charts made in conjunction with the degasser can be compared readily with steam flow, superheat temperature, or other operating charts to obtain a coherent over-all picture of the data.

The conductivity of the gas fraction is measured simultaneously by a second cell. The gas fraction can also be easily diverted for chemical analysis.

Sulphite and Silica in Boiler Water at Springdale, by L. E. Hankison, Mem. ASME, and M. D. Baker, West Penn Power Company, Pittsburgh, Pa. 1949 ASME Annual Meeting paper No. 49—A-75 (in type; to be published in Trans. ASME).

Hydrogen sulphide was first detected in the gases discharged from the air ejector of the main condenser of No. 7 unit at Springdale Station of West Penn Power Company about 6 months after the unit was placed in service. The story of potassium sulphite and its connection with this unit is related. Silica deposition on the turbine blades was quite rapid, and after 8 months' operation it was necessary to sandblast the silica from the blades. The search for the source of this silica, together with the information found, and the corrections applied are also discussed.

The conclusions of the study are as follows:

1 The water circulation in the boiler is satisfactory.

2 Continuous chemical treatment is needed to obtain satisfactory boiler-water conditioning with the maintenance of minimum concentration of conditioning chemicals.

3 Copper will remove sulphite from boiler-water samples. Steel should be used for sampling lines, cooling coils, and discharge tubes for collecting boiler-water samples.

4 Sulphite determinations may be in error if the sample is collected at or above 80 F.

5 Hydrogen sulphide in the water-steam circulation cycle of a power-station unit can produce severe corrosion.

6 Silica contamination of the feedwater system may occur because of failure of design engineers to recognize the possibility of contamination by fly ash.

Coal-Handling Equipment

Philadelphia Electric Company Adopts Mobile Coal-Handling Equipment, by E. C. Russell, Philadelphia Electric Company, Philadelphia, Pa. 1949 ASME Annual Meeting paper No. 49—A-63 (in type; to be published in Trans. ASME).

The Philadelphia Electric Company in 1946 began to make a complete change in its method of handling coal into and out of coal-storage piles. Coal stock piles are maintained for emergency use only and are reclaimed only when there is an interruption of the regular supply.

Coal is delivered normally to all but one of the six generating stations by barge, where it is unloaded by coal-tower clamshell-bucket installations. At the sixth station, barge facilities are not available and rail coal is unloaded into track hoppers.

These mobile units now used are heavy earth-moving machines designed for construction work, self-propelled, bottom-loading, scraper type with four pneumatic tires. They have sufficient power to move their loads at relatively high speeds up 10 per cent grades and unload while moving, but need assistance in loading.

Self-propelled units have the advantage of the greater speed on the longer hauls and are usually more economical than the crawler tractor-drawn scrapers on hauls over 600 or 800 ft on earth-moving work. However, the self-propelled units are favored even on the shorter hauls, for unlike most earth-moving work they are mechanically loaded when storing coal which theoretically is 50 per cent of their operation.

Self-propelled units being rubber-tired vehicles have the added advantage of being better suited for use around paved station yards. They are also readily transferred over the road under their own power to another location. At times it is advantageous to be able to transfer a unit from one station to another to assist in the movement of coal.

Storing and Reclaiming Coal With Earth-Moving Equipment at the Oswego Steam Station, by J. Norton Ewart, Buffalo Niagara Electric Corporation, Buffalo, N. Y. 1949 ASME Annual Meeting paper No. 49—A-98 (mimeographed).

Earth-moving equipment at the Oswego Steam Station of the Central New York Power Corporation has handled in excess of 3 billion ton-feet of coal during its first nine years of operation. Coal is stored in a single pile 100 ft high with no danger of spontaneous combustion. The paper describes the operation of bulldozer carry-all units and presents operating and maintenance costs.

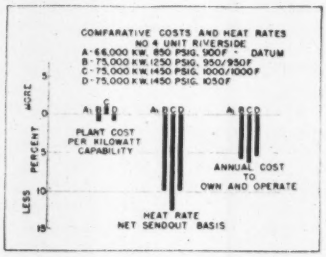
The coal-handling system of the Oswego Station is a simple one and lends itself readily to expansion of the station.

Steam Power

Selection of Steam Conditions for No. 4 Unit—Riverside Generating Station, by R. C. Dannettel, Mem. ASME, and G. S. Harris, Mem. ASME, Consolidated Gas Electric Light and Power Company of Baltimore, Baltimore, Md. 1949 ASME Annual Meeting paper No. 49—A-62 (in type; to be published in Trans. ASME).

In the summer of 1948 the Consolidated Gas Electric Light and Power Company of Baltimore ordered a 75,000-kw capability, 3600-rpm, straight-condensing unit for installation as No. 4 Unit in its Riverside Generating Station. This selection was made after consideration of units both for straight-condensing and reheat cycles and was based upon judgment that the nonreheat unit should be more economical in total dollar costs to the company during the life of the unit.

The nonreheat unit has a single superheater and control and a minimum of high-temperature piping and valves. The use of 1050 F presents no serious



COMPARATIVE COSTS AND HEAT RATES NO. 4 UNIT RIVERSIDE

metallurgical problems. This plant should therefore require less maintenance than a reheat unit.

In comparison with reheat units, the 1450-psig, 1050 F straight-condensing unit should be simpler to install and operate; with less controls should be more reliable and available; should be more adaptable during system disturbances and for frequency regulation; and, considering maintenance and probably light-load operation, should be more economical in total dollar costs to the company during the life of the unit.

The Evaluation of Steam-Power-Plant Losses by Means of the Entropy-Balance Diagram, by Allen Keller, Mem. ASME, General Electric Company, Lynn, Mass. 1949 ASME Annual Meeting paper No. 49—A-65 (in type; to be published in Trans. ASME).

This paper deals with a method of isolating and evaluating the various cycle losses of a condensing steam power plant. Each loss in the steam cycle causes an increase of entropy. By considering each of these entropy increases on a "per hour" basis instead of a "per pound" basis, the heat rejection to the condenser caused by each individual loss can be evaluated quickly.

According to the paper the entropy-balance method is found to be a fundamentally sound and easily applied method of isolating and evaluating the different losses in the steam cycle of a condensing power plant. Although a sizable amount of calculation work is required to make a complete analysis of a given installation, any one question may be answered quite quickly after a heat balance is available. Preliminary estimates of many losses also may be made prior to a heat-balance calculation by making judicious assumptions as to the mass flows involved.

The entropy-balance diagram is not a substitute for other methods of analysis. It is another way of looking at a problem which should be used when it is helpful and not used when other methods seem more straightforward to apply.

A Comparison of Costs of Reheat Versus Nonreheat for 100-Mw Units, by R. P. Moore, Mem. ASME, Buffalo Niagara Electric Corp., Buffalo, N. Y. 1949 ASME Annual Meeting paper No. 49—A-99 (mimeographed).

This paper analyzes the differences in cost of the various elements of a steam-electric power plant, as affected by choice of the reheat or nonreheat cycle applied to units of about 100,000-kw capability.

The data, while presented in as general a form as possible, are based upon units of 100 mw capability in a single boiler-single turbine arrangement with throttle steam at 1450 psig, superheated and reheated to 1000 F. The reheat turbines are reverse-flow, double-flow, single-shaft, tandem-compound units for 3600 rpm with bleeding for regenerative heating. They are compared to nonreheat units of similar arrangement except that the steam passes straight through from throttle to condenser. The fuel is pulverized bituminous coal. Mechanical dust collectors are used.

Some Factors Influencing the Economics of Reheat Installations, by R. W. Hartwell and H. A. Wagner, Mem. ASME, The Detroit Edison Company, Detroit, Mich. 1949 ASME Annual Meeting paper No. 49—A-100 (mimeographed).

Four plant designs were selected for study to provide a means for investigating the economic desirability of: (1) the unit boiler-turbine systems as compared to a battery-boiler system; and (2) resuperheating or reheat as compared to a nonreheat installation. Each plant has an installed capacity of 400 mw in four 100-mw, tandem-compound double-flow, 1800-rpm turbine-generators. Plant A, the battery-boiler system, consists of five interconnected boilers; plant B has four boilers, each connected directly to its own turbine; plant C has four boilers, one for each turbine, which are connected by a crossover; plant D is the unit system as for plant B, but provided with reheat. These plants have totally enclosed boiler rooms and pulverized-fuel-burning boilers equipped with unit coal-pulverizing mills.

Special consideration was given to the effect on over-all cost of: Availability of capacity in each of the schemes; the result of different maintenance schedules on availability; and assignment of capital charges resulting from the difference in average capacity available.

The reheat installation appears favorable economically in all cases, although if 100 per cent capacity charges are assigned, and annual plant factors of 60 per cent or lower are used, the savings in favor of reheat are considerably reduced. In this case, any extra complexity in operation, possible reduction in coal cost, or long-time partial load operation at less than 75 per cent name-plate rating, would militate against a reheat installation.

Turbine-Blade Vibration

Vibration of Marine-Turbine Blading, by R. W. Nolan, Newport News Shipbuilding & Dry Dock Company, Newport News, Va. 1949 ASME Annual Meeting paper No. 49—A-76 (in type; to be published in Trans. ASME).

The purpose of this paper is to give a general explanation of the vibration phenomena encountered in turbine design. Detailed methods have been omitted. The behavior of a vibrating cantilever is expressed in terms of the exciting force and damping factor. The sources of damping and excitation are discussed. Impulse excitation is briefly considered and the reasons for its devastating effects are shown. The procedure of tuning low-pressure blading, to avoid resonance at the lower harmonics of the turbine speed, is explained in considerable detail. An apparatus for determining the natural frequency of blading, and another for applying both tensile and alternating bending stresses simultaneously, are described. The direct tensile stress in the test is plotted versus the alternating bending stress which shows the resistance of the blade to any combination of these stresses. The designed stresses for certain turbine blades and the stresses involved in several blade failures have been plotted on this diagram for purposes of comparison.

Mechanical Design and Testing of Long Steam-Turbine Blading, by H. M. Owens, Jun. ASME, and W. E. Trumpler, Jr., Jun. ASME, Westinghouse Electric Corporation, Philadelphia, Pa. 1949 ASME Annual Meeting paper No. 49—A-64 (mimeographed).

An important economical consideration in the utilization of steam for power generation is the maximum length of blade which can reliably be built for a given turbine speed. Thermodynamic factors determine the optimum flow characteristics and the mechanical designer must then proceed to determine blade areas, section moduli, and lashing which will fulfill reliability requirements of the turbine. The mechanical part of blade design is described in this paper. The problem of designing for centrifugal forces, pressure and torque loads from the steam, and vibratory forces resulting from build-up of some part of the steam forces, does not lend itself to a simple factor of safety analysis. Stresses due

to vibration constitute the major difficulty and are the cause of most blade troubles since failures occur practically always in fatigue.

In considering long blades, we can limit ourselves to those blades whose lowest natural frequencies are six times running speed or lower. In case of a 3600-rpm machine, this would include blades having frequencies of 360 cps or less. This frequency has a tonal sound of about the F above middle C on the piano.

The basic concepts and terminology, the problems of resonance, blade stress, evolution of blade design, turbine-blade tests, measurement of blade frequencies, and measurements of blade stresses are discussed.

Materials Handling

The Profits of Mechanized Handling, by R. C. Sollenberger, Mem. ASME, Conveyor Equipment Manufacturers Association, Washington, D. C. 1949 ASME Annual Meeting paper No. 49—A-128 (mimeographed).

A discussion of the tangible and intangible profits accruing to employer, employee, and community through the use of mechanized handling equipment is presented. Both financial and sociological profits are pointed out and illustrated by case histories in a variety of industries.

The history and growth of the materials-handling industry is cited as one of the contributory factors to the industrial might of the United States and, conversely, the lack of adequate handling and transportation is blamed for the economic backwardness of the undeveloped sections of the world.

The responsibility of the industry for good engineering practice, and responsibility after installation and for constant improvement of equipment and methods are stressed. The need for educating all industry and the general public on the essentiality of mechanized handling to the national strength is a challenge to all materials-handling engineers.

Material-Handling Economies in Pulp and Paper Mills, by Richard Steele MacKenzie, Union Bag and Paper Corporation, New York, N. Y. 1949 ASME Annual Meeting paper No. 49—A-129 (mimeographed).

In this industry the materials to be handled range all the way from the trees which are cut down and removed from the woods, to the logs which are sent in to the mill woodyard and into the chippers, the chips which are sent to the pulp mill, the fibrous pulp in the pulp mill, the pulp in water suspension as it goes to the paper machines, the paper or paperboard as it comes off the paper machines in huge jumbo rolls, smaller rolls for shipment as finished material or for transferring to the converting factories adjacent, the rolls as they are handled on to the converting machines, the bags or boxes as they come off the converting machines (including printing in many plants), the warehousing or shipping of the finished bags or boxes either in tied bundles, sacks, or wrapped bundles. In addition, there is the handling of fuel, chemicals, waste, etc.

In the northern woods where the trees are large, mechanization has been quite well developed. There, heavy tractors, bulldozers, cranes, power saws, and many specialized types of carriers are being utilized.

In the southern woods mechanization has hardly been touched. The reason is quite apparent: the trees are smaller, the terrain is flatter, the ground is apt to be soft and wet, preventing the use of heavy equipment. Furthermore, until recent years, labor costs were so low in these areas that it was hard to justify mechanization from the economic standpoint.

The trend will continue in the direction of a greater use of mechanical means of handling large heavy rolls of paper and board. Such means are floor conveyers, cranes, roll-grabs in conjunction with overhead cranes, delevators, dropalators, etc.

One of the greatest forward steps in the handling and storing of semifinished and finished products has been the use of skids originally, and later, pallets. The use of pallets with lift trucks will continue to accelerate in the converting plants and warehouses.

However the large-scale use of pallets in the distribution field awaits the development of a cheap expendable shipping pallet. To date, the cost of such is too high, but it will somehow be worked down as more attention is given to it. Other than cost, the most serious present limitation is that the small customer is not particularly interested in pallets because he has neither the volume, layout, nor equipment to warrant them, or he is just not interested as yet. The full development of the cheap practical expendable pallet will be the greatest single means of interesting this segment of the industrial and commercial world in material-handling improvements.

Mechanized Aluminum Job-Shop Foundry, by C. H. DeLamater, Aluminum Company of America, Bridgeport, Conn. 1949 ASME Annual Meeting paper No. 49—A-130 (mimeographed).

Alcoa's modernized foundry at Bridgeport, Conn., has incorporated efficient materials handling along with flexibility in their large-scale jobbing-type operations. This foundry regularly handles 200 to 300 pattern changes monthly—occasionally as many as 1000—and is designed to produce both sand and permanent-mold aluminum-alloy castings that range from a few ounces to several hundred pounds.

The most interesting mechanical feature of the plant is its conveyer system which efficiently handles the flow of materials between the different departments which are located in four main buildings having nearly 380,000 sq ft of floor space. Considering materials handling as a whole, the plant actually employs several different conveyer systems. These include mold conveyer trains in the sand foundry; an overhead monorail system for handling molten metal; overhead and underground belt conveyers for transporting molding sand; and an elaborate power and free conveyer system for moving cores, castings, and scrap.

This last-named system, which is unique in application to the foundry industry, has a total length of more than 2½ miles. It is particularly well adapted to a plant of this type where materials must be transferred to different floors of the buildings and where one department feeds into two other departments, or vice versa.

Three different types of conveyer carriers are employed. For transporting cores a rack-type carrier equipped with wheels is used. Rough castings are handled in a box-type carrier. Hopper carriers are used to transport return scrap from the rough trim department to the melting room, and are equipped with drop bottoms for easy unloading.

It was found that material handling resulted in improved working conditions, improved production schedules, and improved flexibility of operation.

Engineering the Belt Conveyer Installation, by Harold Von Thaden, Hewitt-Robins Inc., New York, N. Y. 1949 ASME Annual Meeting paper No. 49—A-136 (mimeographed).

The belt-conveyer industry, a little over fifty years old, is one of the main forces of progress behind the construction, mining, manufacturing, and transportation fields. In sales volume, it

has grown to an estimated $200,000,000 a year.

Belt conveyers have spanned rivers, tunneled through mountains, and reached out under the sea. They have been used to undermine buildings needing foundation repairs.

As long as 25 years ago, a large coal company at Brownsville, Pa., replaced an underground railroad of more than 5½ miles with a belt-conveyer system. Today this system regularly delivers upward of 1800 tons of coal an hour from the work facings, through a mountain to waiting barges on the Monongahela River. A similar installation—going into operation this year near Morgantown, W. Va.—is remarkable for its single conveyer with 10,900-ft centers.

Conveyer installations in many other mines have helped make possible the fact that today, with a quarter of a million fewer miners than in 1920, we can dig 51,000,000 more tons of coal a year.

Conveyerized shore installations also have materially aided the shipper in keeping down his bulk-cargo-handling costs.

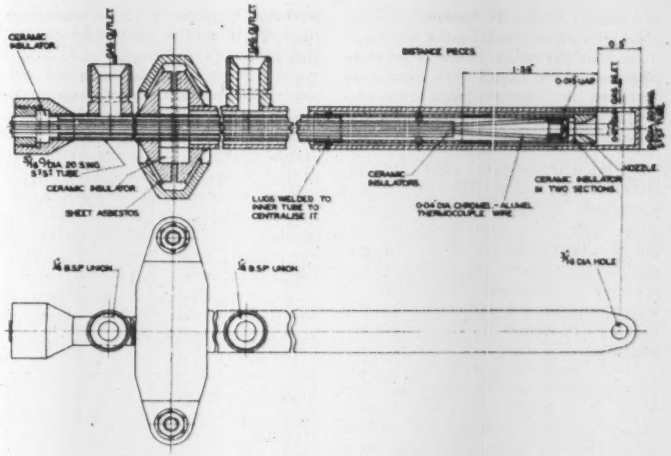
In one instance, a system of movable gantries on the dock that suspend elevators feeding to belt conveyers has so drastically cut down the turn-around time of a ship transporting sugar, that three round trips can be made in the time formerly required to make two.

Many examples of conveying systems now in use are described in the paper. Also discussed are some new ideas and installations which reflect the thinking of the five leading conveyer manufacturers.

Gas-Turbine Power

A Pyrometer for Measuring Total Temperatures in Low Density Gas Streams, by E. P. Walsh, Jun. ASME, J. R. Hamm, Jun. ASME, Westinghouse Electric Corporation, Lester, Pa., and Sidney Allen, Armstrong Siddeley Motors Ltd., Coventry, England. 1949 ASME Annual Meeting paper No. 49—A-66 (mimeographed).

A design of suction pyrometer is presented in which sonic gas velocity is maintained over the thermocouple element at all operating conditions, thus insuring the maximum rate of heat transfer to the thermocouple from the gas, and enabling a simple correction for impact error to be applied to the indicated reading in order to derive the total temperature of the gas stream. The rapid rate of response to temperature change obtained with this pyrometer is a fundamental necessity in any control mechanism in which gas temperature is the operating criterion.



SONIC SUCTION PYROMETER

The paper deals with the reasons for the increase in error in gas temperature measurement under these conditions, describes the development of a suction pyrometer in which sonic velocity is maintained over the thermocouple element, and presents calibration data and service performance of this pyrometer.

In general, the design of the sonic pyrometer described is capable of a high order of accuracy of temperature measurement coupled with a rapid rate of response. These features are evident over a wide range of gas densities, tests having been made at the Armstrong Siddeley Works at pressures varying from about 100 psi abs down to 2 psi abs. So far, only laboratory versions of this type of pyrometer have been constructed. Much smaller sizes of instrument are contemplated to meet the need for a small pyrometer, having a rapid response rate, which exists in gas-turbine engines where a measured temperature operates the control mechanism for the engine. For this application a slow response rate may cause hunting and consequent overheating of the engine. The likelihood of this happening would be greater as the operating altitude of the engine is increased.

The mechanical reliability and the thermoelectric stability of the pyrometer design presented in this paper have proved to be very good. Sonic suction pyrometers have been used for as long as 150 hr without any mechanical problems whatsoever. The accuracy of the pyrometer after 150 hr of operation has been checked and found to be unchanged.

In laboratory tests it has been possible to use the sonic suction pyrometers in any way that ordinary bare-wire thermocouples can be used. They have been used singly for simple temperature traverses, in gangs for traverses of annular passages, and on oscillating multi-instrument rigs for obtaining average temperatures in annular passages.

In general, the need for vacuum lines to the pyrometer has not been a serious disadvantage in laboratory testing, and the relatively high cost of these pyrometers has been justified by the good accuracy and durability obtained.

Metals for Gas Turbines, by Norman L. Mochel, Westinghouse Electric Corporation, Lester, Pa. 1949 ASME Annual Meeting paper No. 49—A-85 (mimeographed).

The author reviews the present metals situation for long-life gas turbines. He points out the need for developing and evaluating materials from the long-life viewpoint, rather than trying to satisfy the needs from short-time data. He discusses the use of metals for the "hot" parts of gas turbines. The construction of gas-turbine rotors is especially covered. There is the suggestion that available alloy fields have been fairly well covered, and that improvement of existing alloys rather than the appearance of many new alloys may be the next stage of development.

Materials for gas turbines can be grouped into two general classes:

1 The high-temperature metals necessary for a comparatively few hot parts, such as the combustion liners, the hot casings and ducts, high-temperature bolts, the rotor of the gas turbine, and

the turbine blades or buckets. (These are thoroughly discussed in the paper.)

2 All those other materials for compressors, gears, auxiliaries, heat exchangers, etc., that probably are available in sufficient development for our present needs.

In high-temperature alloy development, in so far as the 1200–1500 F level is concerned, it appears that the various alloy fields have been fairly well explored. Improvements in this temperature range are more apt to be made by studying the structure, the influence of heat-treatment, and of hot and cold working, than by further alloy variations and additions.

Much time, effort, and money have been expended to develop alloys that might have worth-while load-carrying ability at higher temperature, such as 1600/1750 F. Many alloy fields have been explored. Iron, nickel, cobalt-base alloys, with roughly up to 20 per cent or more of chromium, and with additions up to 7 per cent of molybdenum, to 6 per cent of tungsten, to 4 per cent of columbium have been tried. All sorts of combinations of iron, nickel, chromium, cobalt, tungsten, molybdenum, and titanium have been covered. Some few rays of hope still exist. But there appears to be a growing conviction that we are just about through. Of course there are still to be fully explored: chromium-base alloys, titanium-base alloys, molybdenum-base alloys, and tungsten-base alloys.

Wood Technology

Wood Finishing by Spray Process, by L. W. Lamminan, The DeVilbiss Company, Toledo, Ohio. 1949 ASME Annual Meeting paper No. 49—A-67 (mimeographed).

The treatment of the subject, wood finishing by spray process, is confined to wood as used in the production of furniture in modernly equipped plants doing work on production lines and following through the various stages from start to finish.

Wood-finishing operations in a furniture plant start with the selection and treatment of the solid or veneer woods to be used. Proper kiln drying is an essential before delivery is made to the cabinet or woodworking shop. If veneered wood is used, then the veneer shop must exercise care in laying and pressing the veneer to assure no glue is pressed through the grain or allowed to be deposited on the face of the veneered panels.

Furniture manufacture has kept pace with the progress made in production methods as used in many high-production industries and consequently, today many furniture manufacturers are conveyerized to handle their articles from the woodworking departments through finishing and to the shipping dock. In many plants overhead conveyers with suspended pallets serve as assembly lines in the woodworking or cabinet departments, carrying the article until it is finished. After complete assembly and the preparatory finishing has been thoroughly accomplished, the article, in white, is conveyed to the finishing room where the various finishing operations start in logical sequence.

Transparent finishes retain the natural beauty of such woods as walnut, mahogany, zebrawood, primavera, and maple. In considering the step-by-step procedure, the following coatings and operations are covered: Bleach stain, wash coat, filler, sealer coat, glazing stain, lacquer stain, and clear finishing coat.

Pigmented lacquers and enamels are generally applied to the less expensive woods such as poplar, fir, spruce, etc. No attempt is made to select unusual grain patterns since the finish applied completely hides such patterns. Articles like kitchen cabinets, breakfast, garden, nursery, and some bedroom furniture are finished in these opaque materials. Prefinishing preparation calls for the same careful sanding operation as on natural finished furniture. The smoothness of the base wood is an important factor in the quality of the final finish.

Pigmented finishes may be carried through practically the same finishing operations of the transparent finishes such as rubbing and decorating by antiquing or glazing.

Finishing equipment, operation of equipment, and material control are also covered in the paper.

Portable Pumpers and Hose for Forest Fire Fighting, by J. M. Flounders, Jun. ASME, B. F. Goodrich Company, Akron, Ohio, and R. B. Sargent, Mem. ASME, Hale Fire Pump Company, Conshohocken, Pa. 1949 ASME Annual Meeting paper No. 49—A-112 (mimeographed).

This paper is a résumé of work which has been done to date on portable pumpers and fire hose by the joint Society of American Foresters—American Society of Mechanical Engineers Forest Protection Committee. The purpose of this committee is to encourage and to assist in the development of all types of forest protection and fire-fighting equipment and the eventual development of standards of performance and quality. Radio, groundbreaking equipment, air-borne equipment from packaged food to water bombs, spark arresters and wetting agents are some of the many other problems under consideration by this joint committee.

Desirable characteristics of a portable pumper are high pumping performance; low weight; reliability, running, and starting; ruggedness; and ease of operation.

The authors discuss test procedure and standard test forms for evaluating performance of portable pumping units. A weight performance ratio criterion is used. New developments in hose for forest service use are described and evaluated.

Finishing Fine Furniture and Reproductions, by Ralph Keller, W. & J. Sloane, Ridgefield, N. J. 1949 ASME Annual Meeting paper No. 49—A-113 (mimeographed).

Before it is possible to obtain a fine finish on a high-grade piece of furniture it is of utmost importance that the proper veneers and lumber be carefully selected so that they will be appropriate for the design and period intended in the finished product.

Second, it is absolutely essential that the veneers and lumber be properly seasoned and kiln-dried. The plywood should have a sound clear core, free from stresses and other defects. It should be properly seasoned to avoid sunken joints because it is practically impossible for a finisher to remedy these defects in the finished article. Assuming that the veneers and lumber have been properly seasoned, it must be properly constructed and the drawers must be hand-fitted to close tolerances. The furniture must be hand-sanded prior to the finishing operations.

Three finishing procedures are described in the paper: (1) The finishing of fine mahogany reproductions, (2) the finishing of bleached fine furniture, and (3) the finishing of fine reproductions that require painting and decorating.

Late Developments in Finishing Materials for Wood Products, by Milton A. Kindig, Manager, The Sherwin-Williams Company, Newark, N. J. 1949 ASME Annual Meeting paper No. 49—A-114 (mimeographed).

The latest and most promising development in the finishing of wood furniture is the inclination of the more progressive producers to elevate sharply the level of

finish quality. More and more, the appraisal of quality is coming to include careful judgment of durability factors.

There have been available during the past year lacquer sealers and top coats which fall into the general category which used to be designated as "royalty," but which can be produced as a considerably lower per gallon figure.

They differ from typical lacquers primarily in the fact that they have a slight amber cast which, rather than being a disadvantage, in many cases actually lends to the appearance of fullness.

Prior to the war the use of heat-converting varnish top coats had started in a small way. Since the war, that type of product has enjoyed increasing acceptance and has shown itself to advantage in providing high build in one coat, outstanding toughness, great resistance to solvents and chemicals, and considerable improvement in check resistance. In general, it can be said that a good heat-converting varnish has most of the advantages of either ordinary varnish or lacquer, with very few of their disadvantages.

Recognizing the necessity for additional capital investment in most cases to prepare for the use of heat-converting varnishes, the finishes industry is finding means to eliminate forced drying by providing a similar product which accomplishes its drying chemical reaction through the use of a catalyst rather than application of heat.

The catalyzed varnish is beginning to get the experience of widespread usage and the results indicate a worth-while future.

For the television industry, because of variable operating temperatures, lacquer finishing systems have been developed which may or may not utilize synthetic sealer, but which do have remarkably better resistance to hot and cold checking than finishes of the past.

The television lacquer system, while notable for its check resistance, likewise offers much from the standpoint of toughness and adhesion.

The use of hot-application lacquers and high-solids cold-application lacquers are finding a greater place in the furniture plant, providing good film quality with a reduced number of finishing operations.

A new product which has possibilities of most widespread application is the latest refinement of synthetic sealer.

Building materials such as resin-sealed plywood, resin-sealed doors, door primers, and wood sealer toxic were also briefly described.

Improved Nails, Their Driving Resistance, Withdrawal Resistance, and Lateral Load-Carrying Capacity, by Prof. E. George Stern, Mem. ASME, Virginia Polytechnic Institute, Blacksburg, Va. 1949 ASME Annual Meeting paper No. 49—A-115 (mimeographed).

Approximately 3600 tests were performed on the driving resistance, withdrawal resistance, lateral load-carrying capacity, withdrawal, and deformation of 2, 2½, 3, 3½, and 4-in-long plain-shank, spirally grooved, and annularly grooved nails in southern yellow pine, white oak, and beech, in order to make available comparative test and design information on these nails.

Data on nail properties, as influenced by nail type, size, point, shank pilot, steel composition, heat-treatment, cement coating, wood species, wood density, and annual rings of the wood are presented to help in determining the type of nail most suitable for specific applications.

Some of the findings are as follows:

1 With relatively small increases in driving resistance of nails, large increases can be expected in both withdrawal resistance and lateral load-carrying capacity.

2 Spirally and annularly grooved nails offer larger withdrawal resistance and lateral load-carrying capacity than plain-shank nails. Annularly grooved low-carbon-steel nails offer a larger withdrawal resistance than spirally grooved low-carbon-steel nails, while the withdrawal resistance of spirally and annularly grooved hardened high-carbon-steel nails is approximately the same.

3 Both under withdrawal and lateral load, plain-shank and spirally or annularly grooved nails have similar rigidity within their design ranges, and thus cause similar stiffness of nailed joints.

4 Under constant rate of withdrawal, plain-shank nails retain, within given limits, a slowly decreasing holding capacity somewhat below the ultimate holding capacity; spirally grooved nails continue to increase their holding capacity, although at a decreased rate of increase, after the "initial ultimate withdrawal resistance" has been reached; annularly grooved nails reach a considerably greater ultimate withdrawal resistance at a larger withdrawal than plain-shank and spirally grooved nails, while this withdrawal resistance decreases at a similar rate to that of increase up to the ultimate.

5 Cement-coating results in considerably increased withdrawal resistance of plain-shank nails immediately after driving into low-density southern yellow pine and in almost negligible increase in withdrawal resistance for high-density beech. However, cement-coating does not increase withdrawal resistance or lateral load-carrying capacity of spirally or annularly grooved nails.

Production Engineering

The Manufacture of Panels for Mounting Apparatus Used in Communications Equipment, by A. S. Muessen, Western Electric Company, Inc., Kearny, N. J. 1949 ASME Annual Meeting paper No. 49—A-119 (mimeographed).

This paper describes the methods which have been developed for manufacturing small lots of differing mounting plates economically by reducing set-up and machining time.

Four types of mounting plates are in general use: The flat narrow type arranged for mounting a single row of apparatus; the channel-type plates also arranged for mounting a single row of apparatus; flat panels similar to the flat narrow plates, except that they are made to various widths and mount two or more rows of apparatus; and flanged panels.

Each group of plates presents its own problems. Generally, the apparatus is used interchangeably on all types of plates and the same openings must be provided in all of the different types. Certain openings, have been modified and standardized, where possible, to permit the most economical method of manufacture. The use of a punch and die for perforating an opening complete in one stroke of the press is preferred over any other method and every effort is made to design openings of such size and shape as will lend themselves to this method. In order to keep the number of tools required to a minimum, efforts are also made to design the openings to accommodate as many different pieces of apparatus as possible.

The tooling and methods and some of the results of engineering development work carried on over a period of years are described. In a shop which normally employs about 100 operating people these facilities and methods have reduced skilled layout and machine set-up effort by a good many thousands of hours a year. The replacement of hand bench work with machine and tool controlled operations has also resulted in substantial improvement in over-all product quality. Many of the methods described have been extended to products other than mount-

ing plates including steel framework and sheet-metal casing production.

A Study of Cutting-Face Finishes and Treatments on Twist-Drill Performance, by Charles E. Bierwirth, General Motors Corporation, Flint, Mich. 1949 ASME Annual Meeting paper No. 49—A-120 (mimeographed).

This study was undertaken to determine the effect which different cutting-face finishes and treatments have upon twist-drill performance. The purpose of this study was to obtain knowledge from actual production tests and to record and analyze this information. Thus the information obtained in these tests offers guidance in solving future tooling problems at Buick Motor Division where the surface condition of the cutting face of a twist drill may be involved.

The method of approach to this problem began with a study of all available information on twist drills, surface treatments, surface finishes, and also surface-finish measurement. Preliminary study then led to the selection of two production drilling operations; one on a cast-iron intake manifold with a $^{7}/_{16}$-in-diam hole, and the other on a forged steering knuckle with a $^{27}/_{64}$-in-diam hole. Both of the operations provided close control of speed and feed and supplied an accurate count of the number of pieces machined. Care was taken in both cases to maintain the metallurgical aspects of the material within the defined limits.

The drills used in this test were of two different types of steel; T-1 (tungsten) and M-2 (molybdenum). On each of the two types of steel eight surface finishes and treatments were tested.

A record was kept of each drill's dimensions, the amount removed per grind, the number of pieces machined per grind, and the reason for the drill failure.

A few of the conclusions reached as a result of this study are as follows:

1 In drilling cast iron, drills made of T-1 steel had a performance 112 per cent better than drills made of M-2 steel.

2 For drilling a steel forging, drills made of M-2 steel had a performance 43 per cent better than drills made of T-1 steel.

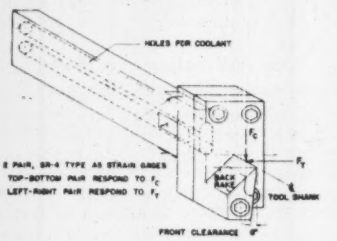
3 In reconditioning the drills used on cast iron, the M-2 steel drills had 15.5 per cent more stock removed than T-1 steel drills.

4 In reconditioning the drills used on the steel forging, the M-2 steel drills had 25 per cent more stock removed than T-1 steel drills.

Correlation of Plastic Deformation During Metal Cutting With Tensile Properties of the Work Material, by Prof. J. T. Lapsley, Jr., Prof. R. C. Grassi, Mem. ASME, and Prof. E. G. Thomsen, University of California, Berkeley, Calif. 1949 ASME Annual Meeting paper No. 49—A-121 (mimeographed).

An experimental correlation of plastic deformation occurring during metal cutting with the plastic deformation in tension of the work material is given. An analysis permitting comparison of these two states of strain is presented.

Orthogonal cutting of seamless-steel tubing was employed for feeds of 0.0025 to 0.0085 in. per revolution and positive rake angles of 25 to 45 deg. Deformation and forces of cutting were obtained from chip measurement and from a tool dynamometer employing resistance strain gages.



SCHEMATIC DRAWING OF TOOL DYNAMOMETER USED IN MEASURING THE ORTHOGONAL CUTTING FORCE COMPONENTS, F_c AND F_t

The results of the investigation show that metal-cutting data can be correlated with tension data for orthogonal cutting and the test conditions employed; the tension properties of a material may offer a useful index of cutting performance; the work done by shear deformation calculated from metal-cutting data results in larger values than that determined from the tension test for equivalent states of deformation; and further application of the plasticity theory should yield information which could give a more basic understanding of metal cutting.

The Quality-Control Indicator—An Automatic Version of Statistical Control Charts That Pays Off in Reduced Rejects, by R. C. Miles, General Electric Company, Erie, Pa. 1949 ASME Annual Meeting paper No. 49—A-122 (mimeographed).

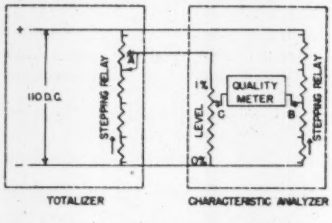
A new device, the quality-control indicator, which automatically performs the principal functions of control charts for per cent defective is described and discussed. "Quality" is indicated continuously by a meter. If the meter needle is in the green portion of the scale, a normal percentage of rejects is present; if the needle moves into the red portion of the scale a new or unusual trouble is indicated and corrective action is called for.

The quality-control indicator has two basic parts: the totalizer, which counts the number of inspected parts or production, and the characteristic analyzer, which counts the number of rejects for one quality characteristic and relates that number to the upper control limit for the production at that time as indicated by the totalizer. The counting is accomplished by means of solenoid-operated rotary stepping relays. The totalizer solenoid is impulsed by closing a set of contacts each time a unit is inspected. The characteristic analyzer solenoid is impulsed by closing another set of contacts each time a reject is found.

The counting operation of the stepping relays is both mechanical and electrical. A numbered dial attached to the shaft of the relay shows the count of units inspected through an escutcheon on the front panel of the totalizer; the count of rejects is shown by a similar arrangement on each characteristic analyzer.

Once the totalizer units and characteristic analyzers are installed, together with the necessary equipment to feed in units produced and rejects found, the control of quality is greatly simplified. Each characteristic analyzer is set to operate at the quality level which applies and the quality-control indicator becomes the watchdog over quality. Each quality meter shows continuously the quality story for that characteristic. Normally, there would be no need for investigation as long as the needle is to the left of mid-scale in the green area. Should a needle move into the red portion, an immediate investigation is made.

It is possible also to observe relative quality by noting the deflection of the needles. A needle which is far to the left end of the scale indicates very good quality; a needle which is shifting



SCHEMATIC DIAGRAM OF CIRCUITS IN TOTALIZER AND CHARACTERISTIC ANALYZER

toward mid-scale indicates a possible epidemic of trouble, and of course the farther the needle moves into the red the worse the trouble is.

Experience to date with the quality-control indicator has shown that in virtually all cases of an out-of-control indication, the cause was found at that time and corrective action was taken immediately.

Automatic Data Analyzer

A Description of an Automatic Data Analyzing Machine, by Bernard S. Benson, Douglas Aircraft Company, Inc., Santa Monica, Calif. 1949 ASME Annual Meeting paper No. 49—A-109 (mimeographed).

During recent years, great advances have been made in collecting and recording data relating to physical phenomena. A wealth of information is steadily accumulating in many fields, notably aeronautics where wind-tunnel tests, airplane and missile flights are producing vast quantities of experimental data. The significance of much of the information is often hidden, as the records are usually in code, scrambled and uncalibrated, in a form most unsuitable for the recording equipment. This is particularly true where a radio link connects the instruments to the recorder. The task of deciphering such records, applying the necessary computations, and presenting the results in a graphic form suitable for direct reference, or in electrical-impulse form suitable for assimilation into automatic computers, is extremely laborious. In the past, much of the recorded material has been left unused, or has not been made available in time to be of direct value. In short, work in the field of data reduction has not kept abreast of developments in data collection.

The Douglas Aircraft Company, therefore, has created a versatile new machine which automatically reads, counts, sifts, scans, decodes, corrects, and plots multiple quantitative instrument records gleaned from line pictures on film. This machine, which has been in successful operation and saved a great deal of time and labor, is described in the present paper, particularly in its application to guided missiles. It has been designed and built for the automatic analysis of bar-graph records.

The function of an automatic analyzer may be broken down into two main parts, the first involving the assimilation and decoding of the data from their original recorded form, the second the application of routine computations. These latter are necessary for calibration purposes if the analyzer is required to yield a graphic output, and often desirable even if the data are merely to be fed directly into another automatic calculating machine for correlation with material from other sources.

The machine comprises essentially a film projector and a screen associated with a photoelectric cell, counting circuits to determine the location of selected lines, and measuring networks to determine and record their lengths.

Management

Control of Maintenance Cost From a Practical Viewpoint, by Howard Bishop, The Youngstown Sheet and Tube Company, Youngstown, Ohio. 1949 ASME Annual Meeting paper No. 49—A-124 (mimeographed).

A practical viewpoint of the control of maintenance costs is given in this paper. Two distinct but closely related activities, preventive maintenance and emergency repairs, are singled out.

Preventive maintenance is a constant effort to prevent equipment failure, and maintain quality of product through periodic inspection, adjustment, repair, and overhauling of equipment.

Emergency repair is the repair or adjustment of equipment after it is broken down or has begun to operate improperly.

The control of maintenance costs begins in the engineering and purchasing of equipment, therefore equipment suitable for the work to be performed should be procured. In existing installations the type and condition of the equipment should be considered.

Factors such as organization, labor costs, proper supervision, and administration of maintenance work are also important.

Industrial Engineering—The Obligation of Management to Control Costs—"How," by D. M. Voitsberger, The S. S. White Dental Manufacturing Co., Philadelphia, Pa. 1949 ASME Annual Meeting paper No. 49—A-125 (mimeographed).

The paper points out that the "how" for controlling costs are: good supervision, proper training, and placement of personnel, good engineering and tooling, efficient purchasing of materials, competent inspection, proper coverage by time study, careful planning and scheduling of work so that operators are free to produce and are not held back by shortages, proper information to aid foremen in laying out their work and distributing operators where they are necessary and in a manner to avoid being overorganized.

Further control of costs should result in consistent reduction not alone in direct costs but in overhead costs throughout the entire organization.

Control should not float with the current or tide through the revision of cost budgets in rising or falling markets. Cost control is fighting the current constantly, making headway toward cost reduction despite adverse conditions. Cost control to be effective must be placed in the hands of one fully authorized and recognized as such, to make decisions and recommendations together with complete and detailed reports to management.

ASME Transactions for January, 1950

THE January, 1950, issue of the Transactions of the ASME, which is in two sections, contains the following:

SECTION 1

Solid-Type Journal Bearings in High-Speed Freight Service, by E. S. Pearce, R. J. Shoemaker, and I. E. Cox. (48—A-128)

The Development of a Design of Smokeless Stove for Bituminous Coal, by B. A. Landry and R. A. Sherman. (48—A-119)

Corrosion-Erosion of Boiler Feed Pumps and Regulating Valves at Marysville, Second Test Program, by J. M. Decker, H. A. Wagner, and J. C. Marsh. (48—A-118)

The Forces and Moments in the Leg During Level Walking, by B. Bresler and J. P. Frankel. (48—A-62)

Report on Graphitization Studies on High-Temperature Welded Piping of The Philadelphia Electric Company, by J. B. Abele and A. E. White. (48—A-94)

Development of the Hydraulic Design for the Grand Coulee Pumps, by Carl Blom. (49—SA-8)

Heat-Conduction Errors in Temperature Measurements, by L. E. Smith (49—S-35)

Fatigue Tests on Flanged Assemblies, by A. R. C. Markl and H. H. George. (49—S-6)

Modern Mercury-Unit Power-Plant Design, by H. N. Hackett and Dwight Douglass. (49—S-17)

SECTION 2

Society Records (Including Indexes to Publications for 1949)

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Heat Transfer

HEAT TRANSFER (VOLUME I). By Max Jakob. John Wiley and Sons, Inc., New York, N. Y., Chapman and Hall, Ltd., London, England, 1949. Cloth, 5¾ × 9 in., illus. Bibliography, xxix and 758 pp., $12.

Reviewed by Charles E. Lucke[1]

THE author's objective is "to show the development of the ideas which led to the present state of our knowledge in the branch of science and engineering called heat transfer," and in his opinion "only a rather international survey would cover the high lights in the path of development, in particular. . . .the German literature of the 25 years before Hitler." In this period the author, holding a position of authority in the German Bureau of Standards, was himself active in experimental and analytical investigations, known to and respected by others interested in the subject throughout the world.

Concerning the method of presentation, the author believes that the book "should serve the needs of mechanical, chemical, electrical, and civil engineers, and physicists alike." This raises a question as to the needs of these four branches of engineering practice, and the one branch of the exact sciences, especially as to how many of these needs can be met by one book and how many of the needs of each require a different treatment of the subject to be acceptable as a useful tool.

There is a clearly defined difference between the objectives of a branch of science and those of a branch of engineering, additions to the laws of nature characterizing the former, and usefulness the latter, especially salability, in a competitive market of a product or service, transportation, for example. While of course engineers must and do have some familiarity with the scientific basis for these things, this is no substitute for the technology which connects the basic principles to the product or service—the salable thing—and the processes involved in its production which establish the relation between design and performance. The best engineering book on the technology of heat transfer would be a quite different thing from the best scientific book on the physics of heat transfer.

The Introduction indicates that the author regards heat transfer as being a branch of science: "Heat transfer is a rather complex section of science. . . .the science of heat transfer cannot be considered a single branch of science. . . . Heat transfer. . . .deals with almost all branches of physics; mechanics, heat, acoustics, optics, and electricity. The development and application of the science of heat transfer are further based on mathematical analysis, and it may be added that both physics and mathematics have not only served in, but have been greatly enriched by, the studies of heat transfer."

Engineers, dealing with heat-transfer problems mainly of industry, fall into three classes: Designers of equipment; operators of that equipment; and analysts who neither design nor operate, but who concentrate on collecting and analyzing records of performance in relation to design, use all available basic principles, including those of physics, test data, and operating records, and predict new relations, acceptable to the designer, which compose the technology of heat transfer. Acceptability to the designer of equipment is the criterion of value in engineering heat transfer.

In the light of the foregoing, the subject matter of the text may now be examined and classified or appraised.

The 754-page treatment of the subject in this first volume is divided into five parts, A to E inclusive, with five appendixes and an introduction. Since parts A and B are in a sense definitional in character, attention can be concentrated on parts C, D, and E, with 537 pages, almost 70 per cent of the total.

The plan of the treatment is based on a classification of all heat transfer into three parts: conduction, convection, and radiation, which the author defines in the introduction as follows:

"Heat conduction considered from an atomistic point of view, is due to the elastic impacts of molecules in gases, to longitudinal oscillation in solid nonconductors of electricity, and to the motion of electrons in metals. From a phenomenological point of view, it means the exchange of heat between contiguous bodies or parts of a body which are at different temperatures. The basic law of heat conduction is in complete analogy to the law of electrical conduction."

"Heat convection is the transportation and exchange of heat, due to the mixing motion of different parts of a fluid. It is governed by the laws of fluid dynamics in combination with the law of heat conduction."

"Heat radiation is identical with light radiation and belongs therefore to optics in its geometry as well as in its dynamics. Speaking of heat radiation means only that the main interest is focused on the influence of temperature upon that kind of energy transportation through a transparent medium or the empty space, which is called radiation."

Following these definitions, the author sets down the basic equation in integral form for the heat transferred hourly in terms of the controlling variable for each, involving the conductivity, the "surface or film coefficient" for transfer between a fluid and a solid surface in contact, and emissivity of radiation to or from a surface.

These three basic relations are next developed in some detail into partial differential equations—the basic equation of heat conduction in chapter 2; the basic equations of heat convection in chapter 3, with the equation for flow of fluids; and the basic equation of heat radiation in chapter 4, with some explanations of phenomena involved, including gas radiation and absorbtion.

As these equations involve certain physical properties of matter, these must be known and their significance understood. This is the subject matter of part B, chapters 5, 6, and 7. "In this part of the book we shall not deal with the methods used for determining numerical values of these properties, but only with the results, i.e., what values seem to be the most reliable, their order of magnitude, and how changes with physical conditions, as temperature and pressure, can be explained, whether and how far some of the properties are interdependent. . . .It will not be neces-

[1] Professor Emeritus, Mechanical Engineering, Columbia University, New York, N. Y. Fellow ASME.

sary to deal with well-known properties, as density, thermal expansibility, and specific heat, but mainly with viscosity, thermal conductivity, and absorptivity for radiation."

Viscosity is the subject of chapter 5, liquids and gases, general relations or theories and numerical values, including vapors. Chapter 6 deals with thermal conductivity of gases, vapors, and liquids, theory and numerical values; solids, porous and loose, including powders, building materials, amorphous and crystalline nonmetals, refractories, electrical insulators, metals and alloys, theory and numerical values. Emissivity (absorptivity) is discussed in chapter 7—nonmetallic surfaces, metals, and gases.

Treatment of these physical properties is excellent, probably the best conveniently available and usable in engineering work.

Detailed or special forms of the equations for various cases of the heat-conduction process are presented in part C, heat conduction in simple bodies, chapters 8 to 20, inclusive, in 291 pages, about 40 per cent of the total of the book.

The treatment of this subject is not markedly different from what has been available, but is somewhat more rigorous in parts, and there is some new matter involving different solutions of the general differential equation. On the whole this presentation of the subject of heat transfer in solids mainly or wholly by conduction is probably unequaled elsewhere, quite independent of the new matter.

Chapter 8 treats the temperature pattern and heat-flow rate for simple geometric shapes, infinitely wide flat plates, long cylinders, spheres, and cubes, with material conductivity constant, and for the sphere with conductivity varying with temperature. Materials and apparatus for measurement of conductivity is the subject of chapter 9. A new condition or variable, introduced in chapter 10 deals with the temperature pattern in certain geometrical shapes for various distributions of heat produced internally—electrically, for example; by nuclear reaction, as in a carbon pile; by chemical reaction which is to be the subject of volume 2; or by fluid friction.

Still another condition is introduced in chapter 11. This new factor is the heat flow across the boundary of a fluid in contact with one or more faces of the solid in which conduction is taking place. Solution of the equation defining temperature in relation to the surface and the heat-flow rate, is based on the assumption of constant-fluid-boundary thermal resistance, or as the author says, "constant surface coefficient." As this constancy condition rarely exists in engineering practice, the value of the solution equation is correspondingly limited. The forms of solids for which equations are set up include rods of uniform section, with axial heat flow from a heat source or connecting two sources, and plane and cylindrical surfaces with fins of various forms, and with pins or spines.

"In chapter 10, the case of internal heat sources and negligible heat losses was dealt with; in chapter 11, heat losses were considered, but sources were excluded," the author explains. "In.... chapter 12, some cases will be treated where both heat sources and leakage are to be included." This part seems to be mainly of interest in certain conductivity measurement apparatus.

Unsteady-state heat-transfer relations are introduced in chapter 13. "The change of temperature in time which occurs in heat-conduction processes is to be determined from Equation 12 of chapter 2. The solution of this differential equation for various geometrical configuration and boundary conditions (mathematical) has always been a favorite field of activity for mathematicians since the days of Fourier. Fourier's series and methods are still the main tools for the treatment of unsteady-state problems of heat conduction. . . .Here, only the simplest forms of these problems will be dealt with, and even these in a simplified manner that may shock mathematically minded readers." However, these simplified treatments are likely to shock most responsible engineers in industry. The shapes considered are the usual ones, subjected to a sudden change of body surface temperature, and also to a sudden change of environment temperature, the latter involving a fluid boundary conductance ("surface coefficient") that is unknown, and therefore assumed to be constant for purposes of solution. Of course the answer can be no more accurate than the guess as to the boundary conduction value.

The effect of variations of temperature of the body surface or of its fluid environment is first considered in chapter 14—the conditions for the earth in relation to the sun, and for certain parts of some machines, and furnace regenerators, for example. "Again only simple cases will be dealt with,"—a flat plate with periodic changes of surface temperature, one or both, or of the surrounding fluid medium, infinitely thick, or of finite thickness. For each case the equations give the temperature pattern and the alternate heat storage and release varying with time.

Chapter 15 of seven pages deals with some complex cases of heat conduction, and chapter 16 of nine pages is mainly "devoted to the determination of the diffusivity" from the equations of chapters 13 to 15 relating diffusivity to other variables. Chapter 17 supplements the "straight solutions of the differential equations of heat conduction" which would be of interest to few engineers.

"Except for the simplest geometric shapes and boundary conditions the analytical solution of the differential equation of heat conduction is a most cumbersome if not impossible job. Approximate solutions may be obtained by numerical, graphical, or experimental methods." Chapters 18 to 20 are devoted to these methods.

For engineers dealing with problems of this class, this is probably the best collection of practical methods, but it is to be noted that problems of this class are of interest to a smaller fraction of engineers in industrial practice than other problems not yet discussed.

The remainder of the book—Parts D and E—a survey of the literature on thermal conductance or resistance of fluid boundaries, including radiation; thermal conductance of fluid boundaries, the reciprocal of which is resistance under any operating condition; operating heat-transfer equipment, designated by the author as the surface coefficient, film coefficient, or just coefficient, of heat transfer—is a matter of primary interest to all engineers dealing with industrial heat-transfer problems. To such engineers the subject matter of these last 275 pages would appeal more strongly than the preceding 420 pages, but of course the mode of treatment would exert a controlling influence. The book treatment is primarily of scientific or analytical character, rather than that of professional engineering practice, but it is decidedly sound and scholarly. The resistance of a fluid boundary across which heat is being transferred in any two or all possible modes where conductances are additive, and the total resistance, from one fluid as a source to another one as a receiver, is the sum of all resistances in series, probably the most common and important engineering condition, is not considered.

The author divides his treatment into two parts, one for the boundary of a fluid flowing past a solid surface while gaining or losing sensible heat and changing temperature accordingly, and the other in which there is a change of phase at the surface with latent heat gained or lost without change of fluid temperature as in boiling or condensation. The two may occur together, a mixture of gases

and vapors gaining or losing vapor, evaporation rather than boiling, a mass exchange.

Part D of the book, heat convection without change of phase or constitution, chapters 21 to 27, inclusive, is a review of equations for hourly sensible-heat transfer across the boundary of a flowing fluid changing temperature according to its specific heat. There is some theorizing, and philosophic interpretation of phenomena, seeking a basis for development of rational equations for the boundary conductance as a function controlling variables for certain specified conditions of operation or of geometry. In chapter 21, laminar and turbulent flow are identified and free convection is distinguished from forced convection, after which mean velocity, temperature of the flowing fluid, and temperature difference between two flowing fluids are expressed in differential equation form.

"Straight solutions of the differential equations. . . .have been found in only a few cases and only under certain simplifications of the considered problems. However, by employing the principle of similarity to these equations, a multitude of important results and much insight into the complex mechanisms of convection processes have been obtained. The greater part of the chapter dealing with convection will be devoted to this principle and to that procedure of its application which is known as dimensional analysis."

Development of rational equations for the fluid-boundary conductance under various conditions of convection heat transfer is the subject matter of chapter 22. The conditions considered include free and natural convection, forced laminar and turbulent flow inside a tube, an annulus, and parallel to a flat surface, at uniform surface temperature or otherwise. For free and forced convection, similarity relations are expounded and applied to the derivation of equations by the differential method and the dimensional method, involving dimensionless functions of variables, in chapter 23, the similarity being between different cases of heat transfer. Similarity between different cases of heat transfer having been dealt with, the author discusses "similarity relations between different components of the convection process, ...based on proportionality between the velocity and temperature field near a heat-exchanging surface. Reynolds made it clear that such proportionality should include the effect of both molecular diffusion and mechanical mixing." This is the subject matter of chapter 24.

A critical review of the literature reporting the results of correlation of experimental determinations of convection heat-transfer fluid boundary conductance, as equations or graphs of rational form with empiric constants, is given for free convection in chapter 25, and for forced convection in chapter 26, for certain geometrical and operational conditions. These may be used as the basis for working formulas by conversion from the dimensional number form, to fluid boundary conductance form with numerical values proper to the engineering system of units including Fahrenheit temperatures instead of the Centigrade used by the author.

"As previously demonstrated, the distributions of velocity and temperature in a thin boundary layer on the surface are decisive for heat transfer by convection. In order to measure these distributions, some instruments such as thermocouples may be placed inside the boundary film, but will disturb the distributions more or less. Optical methods are free from this handicap." This is the opening statement of chapter 27, which ends part E of the book, on convection heat transfer without change of phase and without radiation across the fluid boundary.

Convection transfer with change of phase at the fluid boundary, but still without radiation, is the topic of part E, heat convection including change of phase, chapters 28, 29, and 30. This topic is introduced by a discussion of mass transfer proportional to vapor pressure or concentration differences due to evaporation, condensation at the boundary, with latent-heat equivalents, in relation to heat transfer proportion to temperature differences, in chapter 28. Here basic differential equations are set up; also some special forms for condensation of water vapor from an air-vapor mixture, and evaporation from a liquid surface into a gas stream at the same or different temperatures. A few experimental results are reported for vapor-gas mixtures.

The physical phenomena of boiling a liquid are discussed in considerable detail in chapter 29, even though this "continued one-way migration of molecules into the space of the gaseous phase is not strictly in accordance with the conditions of thermodynamic equilibrium," and it is unusual to consider boiling as a convective process. The results of some experimental measurements are given in the form of equations between variables for boiling at atmospheric or other pressure for certain physical conditions, where bubbles rise freely by buoyancy. These variables do not include rate of circulation of the boiling liquid past the heated surface which is the source of heat with forcible removal of bubbles. This is followed by a statement on the more complicated nuclear boiling in vertical tubes where "the fluid changes in composition, density, and velocity. No wonder, therefore, that our knowledge of the process of boiling in tubes is rather poor." It may be noted that this boiling condition exists in all modern water-tube power boilers, and designers know quite a lot about it.

In the preceding chapter the author considered the difference between nucleate boiling or ebullition, and film boiling of liquid absorption in the spheroidal state, and he introduces chapter 30 by saying, "Corresponding to nucleate and film boiling, two modes of condensing are known, called dropwise condensation and film condensation." . . . "In the following analysis, condensation of steam is preferably dealt with, and a former presentation of the subject by Jakob has been extensively used" (MECHANICAL ENGINEERING, vol. 58, November, 1936, page 729). The difference is primarily a matter of wetting or nonwetting of the surface, thus forming films or drops. While for certain limited conditions a general rational form of equation between variables is set up, actual working condition of geometry, size, condensate kind, and noncondensable additives remain to be treated empirically through test and regular operating data in service.

At the end of the text is found the statement that the main subjects of volume II (in preparation) will be: part F, heat radiation in spaces of simple configuration; and part G, selected field of application.

With the preceding summary of the contents of this book, it seems necessary in the interest of prospective readers at least to point out what is not in the book, and that would be considered of value to designing and operating engineers in the field of heat transfer. These omissions may be considered as consisting of two broad classes, not only omitted, but ignored.

The first of these is working equations of rational form with empirical constants for the boundary resistance of any fluid under any of the circumstances that may exist in full-scale commercial heat-transfer apparatus of all sorts, sometimes classified as heat exchangers, and the over-all resistance between the higher-temperature source of heat and the lower-temperature receiver. This includes all sorts of gas, liquid, vapor, and solid heaters and coolers, vapor condensers, and liquid evaporation.

The second omission is the basic equa

tion, with corresponding working equation of rational form for the heat absorbed by the surroundings of any combustion chamber, the exit-gas temperature, and the heat remaining as sensible heat of exit gases, for any fuels in every sort of fuel-fired equipment, including industrial furnaces, boilers, stills, and the like; also internal-combustion engines and gas turbines.

Applied Experimental Psychology

APPLIED EXPERIMENTAL PSYCHOLOGY: Human Factors in Engineering Design. By A. Chapanis, W. R. Garner, and C. T. Morgan. John Wiley and Sons, Inc., New York, N. Y., Chapman and Hall, Ltd., London, England, 1949. Cloth, 5¾ × 9 in., 196 illus., 13 tables, Bibliography, xi and 434 pp., $4.50.

REVIEWED BY THEODORE F. HATCH[1]

PSYCHOLOGY is concerned with affairs of the mind and, in popular understanding, has little to do with the physical sciences. Certainly, among engineers there is no general recognition of the practical bearing which psychological factors have upon engineering design. Human requirements in relation to machines and structures have not been generally systematized and translated into engineering terms for equal consideration with physical requirements in design procedures. This volume is especially interesting and significant, therefore, because it demonstrates that there is a branch of applied psychology which may be properly termed "engineering psychology." That is to say, man's psychological, as well as physiological, capabilities and limitations can be described and related to physical factors in the design in terms which the engineer will find directly applicable to the solution of many practical engineering problems. Engineering psychology is only in its beginning stage and, necessarily, the material presented here covers only a small fraction of the many and varied human problems which exist in engineering design. The pattern of coverage, however, and the experimental data chosen for illustration and to aid in developing the significance of engineering psychology, are well selected. No engineer can shun the book for fear that he will be venturing into a strange field unrelated to engineering.

On the contrary, he will find direct and practical treatment of many familiar design problems. One good indication of the engineering approach is the fact that most of the 196 illustrations in the book are in the form of graphs showing quantitative relationships between human capacities and responses and variation in basic design factors.

There are three primary chapters in the book entitled: "How We See," "How We Hear," and "How We Make Movements." In each the subject is treated in a manner common to engineering. It is interesting to discover, for example, the extent to which vision and visual requirements can be described in physical terms, equations, and graphs.

The principles which are developed in each of these basic sections are applied in the following chapters to the considerations of practical design problems, as, for example, in the design of instrument dials and other visual displays, in communication and signaling systems, the design of controls for human use, and in the arrangement of work. Because of the acute human problems which were presented during the war in the design of airplanes, much of the illustrative material which is presented comes from the extensive researches in that field. There is no difficulty, however, in visualizing the many industrial problems to which the rules of design also apply. Machine designers, production engineers, and time-and-motion specialists will find the material especially interesting and useful.

Two early chapters are devoted to elementary statistics which will be helpful to the reader who is not familiar with statistical procedures and their application to scientific inquiries and analysis of data. To complete the volume, the last two chapters are devoted to fatigue and to other important physiological factors in the working environment, including temperature and humidity, air pressure, speed and acceleration, vibration, light, and color. These, too, are treated in a systematic and quantitative manner.

This volume is a valuable contribution to the literature in the important and growing field of human engineering.

[1] Professor of Industrial Health Engineering, School of Public Health, University of Pittsburgh, Pittsburgh, Pa. Mem. ASME.

Modern Arms and Free Men

MODERN ARMS AND FREE MEN: A Discussion of the Role of Science in Preserving Democracy By Vannevar Bush. Simon and Schuster, New York, N. Y., 1949. Cloth, 5½ × 8½ in., 274 pp., $3.50. Also available pamphlet bound, 8½ × 11 in., $1.

REVIEWED BY WILLIAM D. COOLIDGE[2]

IN the words of the author, this is "A book on science and democracy and war and their relations to each other."

No one is better fitted than Dr. Bush to tell of the work of the scientists during the last war and to assess the various factors which made possible their outstanding contributions.

With his training and experience and his close personal contacts, during the war, with the heads of our government and of our military establishment, he is also uniquely qualified to discuss this subject, as he does from a broad philosophical point of view.

From the extensive list of projects, which, as Director of the Office of Scientific Research and Development, came under his active purview, he selects a few and tells a thrilling story of the indispensable role these developments played in helping the armed forces to win the war.

Among these projects, he deals with radar and radar jamming, with radio navigation, proximity fuses, rockets, antisubmarine devices, and the atomic bomb. He also refers to various medical advances made during the war, which saved and will continue to save lives.

He not only deals with these subjects as referred to the past war, but gives an appraisal of their probable value in a future war, and extends this appraisal to radiological and biological warfare. While recognizing the horror connected with the use of these last agencies, even here he comes out with reasonable optimism.

The story well illustrates the importance of having had the research effort of so wide a range, as this yielded a variety of new devices from which the most suitable were chosen as needed, to meet the rapidly and unpredictably changing conditions imposed by the enemy.

It also testifies eloquently to the importance of the secrecy which was maintained in connection with these developments, many of which were largely dependent for their effectiveness on the element of surprise.

Most of the scientific developments of the war fall in the category of applied rather than basic science—the sort of activity constituting the major part of

[2] Director Emeritus, Research Laboratory, The Knolls, General Electric Company, Schenectady, N. Y.

the work of industrial research laboratories.

American industrial research has been built up around the idea of close co-operation, and this can be achieved only in an atmosphere of mutual trust. In such an atmosphere, each worker receives help from his associates and so produces more than he otherwise could. The presence of a single untrustworthy member in such a group, like an infectious disease, spreads its contaminating influence. Effective co-operation in research calls not only for mutual trust, but also for freedom to think and to criticize. It is rendered impossible by regimentation.

We are so accustomed to being free and to trusting one another, that we don't realize what a blessing it is and what an element of strength it gives us.

In stressing this as much as he does, Dr. Bush puts his finger on our greatest advantage over those living in constant fear and working under strict regimentation.

For creative work, he stresses the importance of youth, a thesis which, to the knowledge of the reviewer, has been strongly supported by past studies which have shown that most of our great inventions have been made by the very young.

In discussing our educational system, Dr. Bush urges, for the future, that more special effort be given to the training of the unusually gifted youth.

The reviewer sees that, in spite of the teaching of history, it is easy for us to forget that democracy or any other form of government needs constant effort for its preservation. We read of the decline of past civilizations and may see the ruins testifying to their one time greatness, and we have witnessed what, in our own lifetime, has happened in Europe and Asia, but still we are prone to think that no such thing could happen here.

Dr. Bush is optimistic concerning our future. He is, however, not complacent, and gives us no sleeping potion. He stresses not only the strengths but also the weaknesses of democracy, and indicates broadly how, by purposeful action, our weaknesses can be overcome.

He sees in the world of to-day, two great contrasting philosophies of life. On the one side he sees those who believe that science teaches all there is to know or feel. On the other side, he sees those who have faith that life has meaning, who would follow science where it applies, but reach beyond in aspiration.

The reviewer finds himself so much in sympathy with the book that he can only praise it and recommend it to all, both as an illuminating story of the indispensable role of science in the last and in possible future wars, and for the author's general philosophical point of view.

By his magnificent work during the war in mobilizing our scientific research effort and guiding it to spectacular success, Dr. Bush has placed our nation under a great debt of gratitude, to which he has now added in no small measure by writing this book, which should be compulsory reading for everyone interested in our national defense and the continuation of our way of life.

Materials Testing With X Ray

MATERIALPRÜFUNG MIT RÖNTGENSTRAHLEN. By Richard Glocker. Springer-Verlag, Berlin, Göttingen, Heidelberg, Germany, 1949, Third edition. Cloth, 6 × 9¼ in., 349 illus., Bibliography, VIII and 440 pp., DM 58.

REVIEWED BY JOHN T. NORTON[4]

ALL those interested in the uses of x rays for the study of materials will welcome the new edition of this well-known and highly regarded book by Professor Glocker. It is somewhat enlarged and has the same high quality of printing and paper which is the hallmark of Springer publications. While the new edition follows the same general plan as the earlier ones, a new section has been added on noncrystalline materials and liquids. There are descriptions and illustrations of new equipment which has been developed in recent years.

Of particular interest is the section on the x-ray measurement of stresses in metals which has been considerably expanded and constitutes what is probably the best treatment of this important subject now available.

An important section of the book is a classification and description of the types of crystal structure. In this classification Professor Glocker uses a method of notation of his own rather than that used in the Strukturbericht, which is now generally accepted by workers in the field of crystal structure the world over.

Another point worth mentioning is the question of units in which x-ray wave length and lattice constants are expressed. The author states that 1000 X units = 1 angstrom unit = 10^{-8} cm. In 1946 an international convention fixed the relation between the X unit and the true angstrom unit in such a way that 1000 XU = 1.00202 angstrom units. Examination shows that the author has been consistent in expressing values in X units or KX units throughout the book, although they are called angstrom units, and if the reader keeps this in mind, no confusion should result.

This book covers in an excellent and authoritative way, all of the important x-ray methods and techniques and is heartily to be recommended as an important reference work to the beginner and expert alike.

[4] Professor, Department of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass.

ASME BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code may communicate with the Committee Secretary, ASME, 29 West 39th St., New York 18, N. Y.

The procedure of the Committee in handling the Cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting.

This interpretation is submitted to the Board on Codes and Standards, as authorized by the Council of The American Society of Mechanical Engineers, for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of November 4, 1949, and approved by the Council under the date of December 15, 1949.

CASE NO. 1056 (*Reopened*)

Case No. 1056 which was annulled on October 29, 1948, and published in ME-

CHANICAL ENGINEERING, January, 1948, has now been reinstated. This Case covers fabrication of Par. U-69 vessels with a maximum thickness of 0.58 inch from flanged quality steel of specified chemical and physical requirements.

CASE NO. 1106

Inquiry: Will unfired pressure vessels fabricated by fusion welding under the requirements of Paragraphs U-69 and U-70 meet the intent of the Code if the base metal is copper nickel alloy conforming to Specification SB-171?

Reply: It is the opinion of the Committee that copper nickel alloy conforming to Specification SB-171 may be used for the construction of unfired pressure vessels by fusion welding under the general requirements of Paragraphs U-69 and U-70. For vessels constructed under either paragraph, the welding requirements of Paragraph U-69 and Section IX of the Code shall apply except that:

(1) One qualification test weld shall be made on the minimum thickness and one on the maximum thickness of material that will be used in construction.

(2) The elongation as determined by the free bend test shall be not less than 30%.

(3) Stress relieving is not required.

The rules of Par. U-20 shall be applied by using Table U-3 values for allowable working stresses multiplied by:

(*a*) For Par. U-69 construction 80% joint efficiency.

(*b*) For Par. U-70 construction, the joint efficiency shall be computed by dividing the *SE* values given in Pars. U-70(**a**) and U-70(**b**) by 11,000.

CASE NO. 1107

Inquiry: Is it permissible to stress-relieve Code vessels at temperatures lower than 1100 F as now required under Par. U-76(**c**)?

In support of the reasons for this inquiry, attention is directed to Case No. 896 by which heat-treatment for clad materials is referred to the stress-relief treatment required for the base plate under Par. U-76. There is evidence that the rate of carbide precipitation in certain chrome nickel alloys increases rapidly in the sensitizing range; at 1100 F and higher it may be at a maximum. Heat-treatment at lower temperatures for longer periods is understood to have been used and found equally satisfactory, one such indication being a permissive heating at 1000 F for at least three hours per inch of thickness on forge welding under Par. U-87(**b**).

Reply: It is the opinion of the Committee that when it is impracticable to stress-relieve at a temperature of 1100 F, it is permissible to carry out this operation at lower temperatures for longer periods of time in accordance with the following schedule:

Metal temperature, deg F	Holding time, hr per inch of thickness
1100	1
1050	2
1000	3
950	5
900	10

For intermediate temperatures, the holding time shall be determined by straight-line interpolation. The minimum temperature for stress-relief given above shall be the actual minimum temperature of any part of the plate material of the shell or head of a vessel as determined by thermocouples attached to the vessel.

CASE NO. 1108

Inquiry: May annealed alpha aluminum bronze alloy plate and sheet with the following range of chemical composition:

Copper, per cent	88.00 to 92.50
Aluminum, per cent	6.00 to 8.00
Iron, per cent	1.50 to 3.50
Others, max per cent	0.50

and the following minimum physical properties in the annealed condition:

70,000 psi ult. tens. str.
30,000 psi yield str. at 0.5% elong. under load
40% elongation in 2 in.

and conforming to ASTM B-169-48T Alloy D, be used in the construction of unfired pressure vessels under the provisions of Par. U-68 and U-69 of the Code?

Reply: Annealed alpha aluminum bronze alloy, of composition as noted above, and conforming to ASTM B-159-48T Alloy D, may be used in the construction of unfired pressure vessels under Pars. U-68 and U-69 of the Code with the following limitations:

(1) *Corrosion Resistance*

(*a*) It is expected that vessels of alpha aluminum bronze covered by these rules will be used to hold corrosive liquids and gases. However, the selection of this alloy as being suitable in a specific application shall be the responsibility of the user.

(*b*) The determination of corrosion allowances is not covered by these rules. It is recommended that users assure themselves by appropriate tests, or otherwise, that the alloy is suitable for the service intended.

(*c*) Where service data are not available, the procedure of Par. U-11(**b**) should be followed.

(2) *Design*

(*a*) The maximum allowable design stresses shall be as follows:

TABLE 1

Temp	Allowable working stress	Allowable stress for bolts
Subzero to 150 F	17,000 psi (1/4 t.s.)	6,000 psi (1/5 y.s.)
200	16,600 psi (1/4 t.s.)	5,900 psi (1/5 y.s.)
300	14,800 psi (0.8 creep)	5,800 psi (1/5 y.s.)
400	11,500 psi (0.8 creep)	5,600 psi (1/5 y.s.)
500	8,000 psi (0.8 creep)	5,500 psi (1/5 y.s.)

(*b*) Since this alloy will be used for handling or storing corrosive fluids, care should be exercised to see that the design considers corrosion problems. All crevices where accelerated local attack may occur should be filled or sealed by fusion welding. These crevices usually are found behind backing strips, lap joints and riveted joints.

(*c*) The outer fibers in the weld metal bend tests shall have a 20% minimum elongation. This value is also the minimum requirement for the all-weld metal tension-test specimen as noted in Par. U-68(**e**) of the Code.

(*d*) No low temperature impact tests are required for this material or for any deposited weld metal, if the composition is within the range of composition of the specifications. If the deposited weld metal does not meet this requirement, impact tests of the weld metal shall be made in accordance with the requirements of Par. U-142. If the impact specimen bends without fracture it shall be considered to have met the requirements.

(*e*) Stress relieving is not required

Proposed Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revisions of the rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place.

The following proposed revisions have been approved for publication as proposed addenda to the Code. They are published herewith with corresponding paragraph numbers to identify their location in the various sections of the Code and are submitted for criticism and approval from any one interested therein.

It is to be noted that a proposed revision of the Code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York 18, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-300. Revise last paragraph as follows:

Parts of boilers, such as superheater, waterwell, or economizer headers, —OR ANY CONSTRUCTION INVOLVING ONLY WELDING AS covered by Par. P-112(a) (1) to (5), inclusive, may be fabricated by a manufacturer in possession of the pressure piping symbol stamp, and so stamped and reported on a Manufacturers' Partial Data Report Form (Form P-4) as called for in Par. P-332(f).

PAR. U-142(a) (2) Delete Par. U-142(a) (2) and substitute the following:

STORAGE VESSELS THAT NORMALLY OPERATE AT ATMOSPHERIC TEMPERATURES BUT TEMPORARILY MAY BE SUBJECT TO TEMPERATURES LOWER THAN —20 F MAY BE CONSTRUCTED WITHOUT THE REQUIREMENT FOR IMPACT TESTING PROVIDED:

(*a*) THAT THE PRESSURE IN THE VESSEL IS A FUNCTION OF TEMPERATURE OF THE FLUID SUCH THAT IT IS NOT IN EXCESS OF 20% OF THE DESIGN PRESSURE AT A TEMPERATURE OF —20 F;

(*b*) THAT THE VESSEL HAS BEEN DESIGNED AND CONSTRUCTED TO MINIMIZE LOCALIZED STRESS CONCENTRATION AND TO AVOID NOTCH EFFECTS;

(*c*) THAT THE VESSEL OPERATES UNDER NO CONSIDERABLE STRESS DUE TO CAUSES OTHER THAN INTERNAL OR EXTERNAL PRESSURE.

PAR. U-19(c) of the 1946 edition of the Unfired Pressure Vessel Code Add the following footnote:

IT IS RECOGNIZED THAT HIGH LOCALIZED AND SECONDARY BENDING STRESSES MAY EXIST IN VESSELS DESIGNED AND FABRICATED IN ACCORDANCE WITH THESE RULES. IN SO FAR AS PRACTICAL, DESIGN RULES FOR DETAILS HAVE BEEN WRITTEN TO HOLD SUCH STRESSES AT A SAFE LEVEL CONSISTENT WITH EXPERIENCE.

PAR. H-51(e) of the Low Pressure Heating Boiler Code—Revise the third sentence as follows:

Relief valves for hot-water boilers shall be tested AT FULL CAPACITY at 3 PSI OVER THE SET PRESSURE.

PAR. H-24(b) of the Low Pressure Heating Boiler Code—Revise as follows:

H-24(b) For unflanged heads in welded boilers operating at not over 15 lb steam or 30 lb water, staying is not required if the GREATEST DISTANCE MEASURED ALONG A RADIAL LINE FROM THE INNER SURFACE OF A SHELL TO A FULLY SUPPORTED LINE OR POINT DOES NOT EXCEED 1.25*p*. For such boilers built with heads set inside of the shell plates so the distance from the end of the shell to the outside face of the head is at least 3 times the shell thickness, staying is not required if the GREATEST DISTANCE MEASURED AS ABOVE DOES NOT EXCEED 1.5*p*. FOR PURPOSES OF APPLYING THIS PARAGRAPH A FULLY SUPPORTED POINT IS A STAY ROD OR TUBE PASSED THROUGH THE HEAD AND WELDED, HAVING SUFFICIENT AREA TO MEET REQUIREMENTS OF TABLE H-4, AND HAVING AREA OF WELD IN SHEAR AT LEAST 1.25 REQUIRED AREA OF STAY MEMBER. A FULLY SUPPORTED LINE IS THE TANGENT TO A ROW OF ROLLED OR WELDED TUBES OR WELDED STAYS NOT OVER 1*p* APART BETWEEN EDGES AND EXTENDING TO WITHIN 1*p* OF THE SHELL AT EACH END, OR A BENT OR WELDED CORNER JOINT.

Section II of the Code Delete Specification SA-27.

Section I of the Code Delete reference to Specification SA-27 in the following paragraphs:

Par. P-9(a)	Par. P-103
Par. P-11	Table P-7
Par. P-13	

Section VIII of the Code Delete reference to Specification SA-27 in Table U-2.

Revise the Low Pressure Heating Boiler Code in accordance with the following report dated June 23, 1949.

PROPOSED REVISIONS TO THE STEEL PLATE SECTION OF THE LOW PRESSURE HEATING BOILER CODE

SAFETY VALVES AND RELIEF VALVES

PAR. H-43(a) Revise first sentence as follows:

(a) Each steam boiler shall have one or more OFFICIALLY RATED safety valves of the spring-pop type adjusted and sealed to discharge at pressure not to exceed 15 psi.

PAR. H-43 Add following new paragraphs:

(d) THE MINIMUM SIZE OF VALVE OR VALVES SHALL BE GOVERNED BY THE CAPACITY MARKING ON THE BOILER CALLED FOR IN PAR. H-68.

(e) THE MINIMUM VALVE CAPACITY IN POUNDS PER HOUR SHALL BE DETERMINED BY DIVIDING THE MAXIMUM BTU OUTPUT AT THE BOILER NOZZLE OBTAINED BY THE FIRING OF ANY FUEL, FOR WHICH THE UNIT IS DESIGNED, BY 1000 OR BY MULTIPLYING THE SQUARE FEET OF HEATING SURFACE BY 5. IN MANY CASES A GREATER RELIEVING CAPACITY OF VALVES WILL HAVE TO BE PROVIDED THAN THE MINIMUM SPECIFIED BY THESE RULES. IN EVERY CASE THE REQUIREMENTS OF (f) SHALL BE MET.

(f) THE STEAM SAFETY VALVE CAPACITY FOR EACH BOILER SHALL BE SUCH THAT WITH THE FUEL-BURNING EQUIPMENT INSTALLED, THE PRESSURE CANNOT RISE MORE THAN 5 LB ABOVE THE MAXIMUM ALLOWABLE WORKING PRESSURE OF A STEAM BOILER.

(g) WHEN OPERATING CONDITIONS ARE CHANGED, OR ADDITIONAL BOILER HEATING SURFACE IS INSTALLED, THE VALVE CAPACITY SHALL BE INCREASED, IF NECESSARY, TO MEET THE NEW CONDITIONS AND BE IN ACCORDANCE WITH (f). THE ADDITIONAL VALVES REQUIRED, ON ACCOUNT OF CHANGED CONDITIONS, MAY BE INSTALLED ON THE OUTLET PIPING PROVIDED THERE IS NO INTERVENING VALVE.

PAR. H-44 (a) Add following sentence:

THE CAPACITY OF WATER RELIEF VALVES THAT HAVE NOT BEEN OFFICIALLY RATED SHALL NOT BE TAKEN INTO CONSIDERATION IN DETERMININO THE REQUIRED RELIEVING CAPACITY.

PAR. H-44 (c) Revise as follows:

The seats and disks OF RELIEF VALVES shall be of material suitable to resist corrosion AND WITHSTAND THE PRELIMINARY TEST PRESCRIBED IN H-45. No materials liable to fail due to deterioration or vulcanization when subjected to any temperature not exceeding [250 F] 275 F shall be used for any part.

PAR. H-44 (d) Revise as follows:

No relief valve shall be smaller than 3/4 in. nor larger than [2 in.] 4 1/2 IN. standard pipe size. The inlet opening shall have an inside diameter approximately equal to, or greater than, the seat diameter. IN NO CASE SHALL THE MINIMUM OPENING THROUGH ANY PART OF THE VALVE BE LESS THAN 1/4 IN. DIAMETER OR ITS EQUIVALENT AREA.

PAR. H-44 Add following new paragraphs

(e) THE STEAM RELIEVING CAPACITY IN POUNDS PER HOUR SHALL BE DETERMINED BY DIVIDING THE MAXIMUM BTU OUTPUT AT THE BOILER NOZZLE OBTAINED BY THE FIRING OF ANY FUEL, FOR WHICH THE UNIT IS DESIGNED, BY 1000 OR BY MULTIPLYING THE SQUARE FEET OF HEATING SURFACE BY 5. IN MANY CASES A GREATER RELIEVING CAPACITY OF VALVES WILL HAVE TO BE PROVIDED THAN THE MINIMUM SPECIFIED BY THESE RULES. IN EVERY CASE, THE REQUIREMENTS OF (g) SHALL BE MET.

(f) WHEN OPERATING CONDITIONS ARE CHANGED, OR ADDITIONAL BOILER HEATING SURFACE IS INSTALLED, THE VALVE CAPACITY SHALL BE INCREASED, IF NECESSARY, TO MEET THE NEW CONDITIONS AND BE IN ACCORDANCE WITH (g) THE ADDITIONAL VALVES REQUIRED, ON ACCOUNT OF CHANGED CONDITIONS, MAY BE INSTALLED ON THE OUTLET PIPING PROVIDED THERE IS NO INTERVENING VALVE.

(g) IF THE STAMPED CAPACITY IN BTU ON THE RELIEF VALVE OR VALVES IS LESS THAN THAT REQUIRED IN SECTION (e) AND (f) OF THIS PARAGRAPH, RUPTURE DISKS OR SIMILAR PRESSURE RELIEF DEVICES OR STEAM SAFETY VALVES WITHOUT WING GUIDES ON THE PRESSURE SIDE OF THE DISK SHALL BE INSTALLED TO CONTROL THE PRESSURE NOT TO EXCEED BY MORE THAN 3 POUNDS ABOVE THE PRESSURE SETTING OF THE DEVICE. WHEN RUPTURE DISKS OR SIMILAR PRESSURE RELIEF DEVICES OR STEAM SAFETY VALVES ARE USED TO OBTAIN THE REQUIRED RELIEVING CAPACITY, THEY SHALL BE SET 15 POUNDS ABOVE THE MAXIMUM WATER WORKING PRESSURE OF THE BOILER OR BOILERS WITH WATER WORKING PRESSURES

UP TO AND INCLUDING 75 POUNDS PER SQ. IN. AND 20% ABOVE THE MAXIMUM WATER WORKING PRESSURE OF THE BOILER OR BOILERS WITH WATER WORKING PRESSURES ABOVE 75 POUNDS AND UP TO 160 POUNDS.

PAR. H-45 Add as new paragraph:

H-45 PRELIMINARY TESTS OF VALVES THAT HAVE NONMETALLIC DISKS. THE VALVES SUBMITTED FOR TESTS SHALL PASS THE FOLLOWING PRELIMINARY TESTS:

(1) SET PRESSURE SHALL BE MEASURED BY A COLD WATER TEST.

(2) THE VALVES SHALL BE COOKED IN A STEAM BATH AT A PRESSURE OF 30 PSIG FOR ONE HOUR.

(3) THE VALVES SHALL BE COOLED WITH WATER.

(4) THE SET PRESSURE SHALL BE RECHECKED WITH COLD WATER. IF THE SET PRESSURE OF ANY VALVE VARIES 5% FROM ITS ORIGINAL SET PRESSURE WHEN TESTED AS PER (1), THE VALVE SHALL BE REJECTED WITHOUT FURTHER TEST.

(5) IF THE VALVES PASS THE ABOVE PRELIMINARY TESTS THEY SHALL BE TESTED FOR STEAM RELIEVING CAPACITY AS STATED ELSEWHERE IN THIS CODE.

PAR. H-46 (c) Delete second sentence and substitute:

WHEN THE SIZE OF THE BOILER REQUIRES A SAFETY VALVE OR RELIEF VALVE LARGER THAN $4^1/_2$ IN. DIAMETER, TWO OR MORE VALVES HAVING THE REQUIRED COMBINED CAPACITY SHALL BE USED.

PAR. H-48 Make last sentence a separate paragraph H-49.

PAR. H-51 (d) Add as second paragraph:

IF A MANUFACTURER WISHES TO APPLY THE CODE SYMBOL TO PRESSURE RELIEF VALVES OR STEAM SAFETY VALVES OF ONE OR MORE SIZES OF A DESIGN SET AT ONE PRESSURE, HE SHALL SUBMIT THREE VALVES OF EACH SIZE OF EACH DESIGN SET AT ONE PRESSURE FOR TESTING AND THE STAMPED CAPACITY OF EACH SIZE SHALL BE 90% OF THE MINIMUM CAPACITY OF THE THREE VALVES TESTED. FOR RELIEF VALVES WITH NONMETALLIC DISKS, THIS METHOD OF DETERMINING RELIEVING CAPACITY SHALL BE USED.

PAR. H-51 (e) Correct $\frac{K}{d}$ to K_d =

$$\frac{\text{Actual steam flow}}{\text{Theoretical steam flow}} =$$

Coefficient of discharge

PAR. H-53 Delete whole paragraph (This paragraph has been incorporated in H-43 and H-44).

PAR. H-68 (a) (3) Replace H-53 with H-43 or H-44.

PROPOSED REVISIONS TO THE CAST IRON SECTION OF THE LOW PRESSURE HEATING BOILER CODE

SAFETY VALVES AND RELIEF VALVES

PAR. H-96 Safety Valves. (a) Revise first sentence as follows:

(a) Each steam boiler shall have one or more OFFICIALLY RATED safety valves of the spring-pop type adjusted and sealed to discharge at a pressure not to exceed 15 psi.

PAR. H-96 Add as new paragraphs:

(d) THE MINIMUM SIZE OF VALVE OR VALVES SHALL BE GOVERNED BY THE CAPACITY MARKING ON THE BOILER CALLED FOR IN PAR. H-120.

(e) THE MINIMUM VALVE CAPACITY IN POUNDS PER HOUR SHALL BE DETERMINED BY DIVIDING THE MAXIMUM BTU OUTPUT AT THE BOILER NOZZLE OBTAINED BY THE FIRING OF ANY FUEL, FOR WHICH THE UNIT IS DESIGNED, BY 1000. IN MANY CASES A GREATER RELIEVING CAPACITY OF VALVES WILL HAVE TO BE PROVIDED THAN THE MINIMUM SPECIFIED BY THESE RULES. IN EVERY CASE THE REQUIREMENTS OF (f) SHALL BE MET.

(f) THE STEAM SAFETY VALVE CAPACITY FOR EACH BOILER SHALL BE SUCH THAT WITH THE FUEL-BURNING EQUIPMENT INSTALLED, THE PRESSURE CANNOT RISE MORE THAN 5 LB ABOVE THE MAXIMUM ALLOWABLE WORKING PRESSURE OF A STEAM BOILER.

(g) WHEN OPERATING CONDITIONS ARE CHANGED, OR ADDITIONAL BOILER HEATING SURFACE IS INSTALLED, THE VALVE CAPACITY SHALL BE INCREASED, IF NECESSARY, TO MEET THE NEW CONDITIONS AND BE IN ACCORDANCE WITH (f). THE ADDITIONAL VALVES REQUIRED, ON ACCOUNT OF CHANGED CONDITIONS, MAY BE INSTALLED ON THE OUTLET PIPING PROVIDED THERE IS NO INTERVENING VALVE.

PAR. H-97 Relief Valves. (a) Add following sentence:

THE CAPACITY OF WATER RELIEF VALVES THAT HAVE NOT BEEN OFFICIALLY RATED SHALL NOT BE TAKEN INTO CONSIDERATION IN DETERMINING THE REQUIRED RELIEVING CAPACITY.

PAR. H-97 Revise (c) and (d) as follows

(c) The seats and disks OF RELIEF VALVE: shall be of material suitable to resist corrosion AND WITHSTAND THE PRELIMINARY TEST PRESCRIBED IN H-98. No materials liable to fail due to deterioration or vulcanization when subjected to any temperature not exceeding [250 F] 275 F shall be used for any part.

(d) No relief valve shall be smaller than $^3/_4$ in. nor larger than [2] $4^1/_2$ in. standard pipe size. The inlet opening shall have an inside diameter approximately equal to, or greater than, the seat diameter. IN NO CASE SHALL THE MINIMUM OPENING THROUGH ANY PART OF THE VALVE BE LESS THAN $^1/_4$ IN. DIAMETER OR ITS EQUIVALENT AREA.

PAR. H 97 Add following new paragraphs:

(e) THE STEAM RELIEVING CAPACITY IN POUNDS PER HOUR SHALL BE DETERMINED BY DIVIDING THE MAXIMUM BTU OUTPUT AT THE BOILER NOZZLE OBTAINED BY THE FIRING OF ANY FUEL, FOR WHICH THE UNIT IS DESIGNED, BY 1000. IN MANY CASES A GREATER RELIEVING CAPACITY OF VALVES WILL HAVE TO BE PROVIDED THAN THE MINIMUM SPECIFIED BY THESE RULES. IN EVERY CASE, THE REQUIREMENTS OF (g) SHALL BE MET.

(f) WHEN OPERATING CONDITIONS ARE CHANGED, OR ADDITIONAL BOILER HEATING SURFACE IS INSTALLED, THE VALVE CAPACITY SHALL BE INCREASED, IF NECESSARY, TO MEET THE NEW CONDITIONS AND BE IN ACCORDANCE WITH (g). THE ADDITIONAL VALVES REQUIRED, ON ACCOUNT OF CHANGED CONDITIONS, MAY BE INSTALLED ON THE OUTLET PIPING PROVIDED THERE IS NO INTERVENING VALVE.

(g) IF THE STAMPED CAPACITY IN BTU ON THE RELIEF VALVE OR VALVES IS LESS THAN THAT REQUIRED IN SECTIONS (e) AND (f) OF THIS PARAGRAPH, RUPTURE DISKS OR SIMILAR PRESSURE RELIEF DEVICES OR STEAM SAFETY VALVES WITHOUT WING GUIDES ON THE PRESSURE SIDE OF THE DISK SHALL BE INSTALLED TO CONTROL THE PRESSURE NOT TO EXCEED BY MORE THAN 3 POUNDS ABOVE THE PRESSURE SETTING OF THE DEVICE. WHEN RUPTURE DISKS OR SIMILAR PRESSURE RELIEF DEVICES OR STEAM SAFETY VALVES ARE USED TO OBTAIN THE REQUIRED RELIEVING CAPACITY, THEY SHALL BE SET 15 POUNDS ABOVE THE MAXIMUM WATER WORKING PRESSURE OF THE BOILER OR BOILERS WITH WATER WORKING PRESSURES UP TO AND INCLUDING 75 POUNDS PER SQ. IN. AND 20% ABOVE THE MAXIMUM WATER WORKING PRESSURE OF THE BOILER OR BOILERS WITH WATER WORKING PRESSURES ABOVE 75 POUNDS AND UP TO 160 POUNDS.

PAR. H-98 Add as new paragraph:

H-98 PRELIMINARY TEST OF VALVES THAT HAVE NONMETALLIC DISKS.

THE VALVES SUBMITTED FOR TESTS SHALL PASS THE FOLLOWING PRELIMINARY TESTS:

(1) SET PRESSURE SHALL BE MEASURED BY A COLD WATER TEST.

(2) THE VALVES SHALL BE COOKED IN A STEAM BATH AT A PRESSURE OF 30 PSIG FOR ONE HOUR.

(3) THE VALVES SHALL BE COOLED WITH WATER.

(4) THE SET PRESSURE SHALL BE RECHECKED WITH COLD WATER. IF THE SET PRESSURE OF ANY VALVE VARIES 5% FROM ITS ORIGINAL SET PRESSURE WHEN TESTED AS PER (1), THE VALVE SHALL BE REJECTED WITHOUT FURTHER TEST.

(5) IF THE VALVES PASS THE ABOVE PRELIMINARY TESTS THEY SHALL BE TESTED FOR STEAM RELIEVING CAPACITY AS STATED ELSEWHERE IN THIS CODE.

PAR. H-99 (c) Delete second sentence and substitute:

WHEN THE SIZE OF THE BOILER REQUIRES A SAFETY VALVE OR RELIEF VALVE LARGER THAN $4^1/_2$ IN. DIAMETER, TWO OR MORE VALVES HAVING THE REQUIRED COMBINED CAPACITY SHALL BE USED.

PAR. H-101 Make last sentence a separate paragraph "H-102."

PAR. H-104 (d) Add as second paragraph:

IF A MANUFACTURER WISHES TO APPLY THE CODE SYMBOL TO PRESSURE RELIEF VALVES OR STEAM SAFETY VALVES OF ONE OR MORE SIZES OF A DESIGN SET AT ONE PRESSURE, HE SHALL SUBMIT THREE VALVES OF EACH SIZE OF EACH DESIGN SET AT ONE PRESSURE FOR TESTING AND THE STAMPED CAPACITY OF EACH SIZE SHALL BE 90% OF THE MINIMUM CAPACITY OF THE THREE VALVES TESTED. FOR RELIEF VALVES WITH NONMETALLIC DISCS, THIS METHOD OF DETERMINING RELIEVING CAPACITY SHALL BE USED.

PAR. H-104 (e) Correct $\frac{K}{d}$ to K_d =

$$\frac{\text{Actual steam flow}}{\text{Theoretical steam flow}} =$$

Coefficient of discharge

PAR. H-106 Delete whole paragraph (This paragraph is incorporated in H-96 and H-97).

PAR. H-120 (a) Replace reference to H-106 (a) with H-96 (a) or H-97 (a).

THE ENGINEERING PROFESSION

News and Notes

As Compiled and Edited by A. F. Bochenek

British Study of American Industry Reveals Great Progress Since 1921

Cost-Consciousness, Free Exchange of Knowledge, Selling Techniques, and Technical Press Help to Cut Costs

A REPORT on "Simplification in Industry" recently prepared by a study team of six British industrial leaders and based on an intensive study of 19 American trade and professional societies and 15 representative American manufacturing plants not only throws the spotlight on American industrial philosophy but also reveals how far American industry has advanced since 1921 when the monumental American report, "Waste in Industry," placed at the door of management and labor a charge of gross inefficiency.

The British report, sponsored by the Anglo-American Council on Productivity of the Economic Cooperation Administration, covers the factors in American industry which make for high productivity and low-cost operation and recommends measures which can be adopted by British industry to promote the economic well-being of the United Kingdom. In timing, subject matter, and the dispatch with which data were assembled and published, it parallels the 1921 American report on waste in industry prepared by The Federated American Engineering Societies (later known as the American Engineering Council) under the leadership of Herbert Hoover. As the work of overseas investigators whose judgments are made against a background of a different industrial climate and because the report offers a direct comparison with conditions as they existed in American industry three decades ago, the British report has significance for American engineers.

Underlying American high productivity and low cost, British investigators, headed by Major General J. S. Crawford, director of the Guy Motors Limited, call attention to four major factors contributing to American affinity for standardization in products, simplification in operations, and rapid application to industrial production of new knowledge. Two of these are states of mind permeating all levels of industry and two are educational practices which stem from the states of mind.

Contributing to American industrial efficiency the investigators found, were: (1) A highly developed cost-consciousness which creates enthusiasm for high productivity and low cost at all levels of industry; (2) a conviction that everyone benefits and no one loses from an interchange of technical knowledge, one which manifests itself in the readiness with which manufacturers share knowledge and discuss production methods even with competitors; (3) an educational process carried on by the American trade and technical press which seeks out with eagerness and persistence information on high productivity and low cost and disseminates it among persons who can apply it; (4) the educational process carried on by industrial sales staffs which aims to persuade consumers of the advantage of standard sizes and products by stressing better delivery and lower cost while discouraging consumer preference for special products by imposing a higher price for special services.

Cost-Consciousness

In marked contrast to the 1921 American report which charged that a majority of the American plants lacked knowledge of cost and had no cost controls and therefore no adequate method of judging fairly or knowing how and where waste was occurring, British investigators in 1949 report that they were "greatly impressed by the enthusiasm for high productivity and low cost displayed on every level in American industry." Wherever they went, they said, they "found persistent eagerness to search out means for raising output from a given plant" and a "highly developed 'cost-consciousness' which impelled managements to seek every possible method of reducing costs." They noted "that no saving in cost or improvement in productivity is too small to be considered." Manufacturers unhesitatingly changed suppliers even after long association if a similar product at a lower cost or of superior quality could be obtained from some other source.

Interchange of Knowledge

Commenting on the freedom with which technical information passes from one plant to another, the British report says, "We found a greater readiness amongst American manufacturers to share their technical knowledge and to discuss production methods with other manufacturers, whether competitors or not, than is general in the United Kingdom." It was an American conviction, they noted, that all derive great benefit from the interchange and no one loses; that there was a disposition to "throw open the factory and to make the whole production line an open shop for others to visit and to view in detail; ..... also a marked willingness to help each other in any difficulties." One company told the investigators that this practice was adopted largely in order to provide a stimulus to their own staff to keep ahead of their competitors.

Influence of Press

The substantial influence of the technical and trade press in the development of high productivity and low cost was acknowledged in the report. The group noted that the American industrial press "seeks eagerly and continuously for information which bears upon high productivity and low cost" and that they were aided by manufacturers who "are generally willing to have their work and its results fully and widely publicized."

Educating the Consumer

While mass production made for lower cost, the study team wanted to know whether or not consumers were opposed to standardization of sizes and products. Based on their study they were able to state, "We believe that the consumer appreciates and expects the advantages of lower costs and greater availability." Behind a consumer acceptance, the report notes, there was a general practice among sales staff "to exercise persistent persuasion upon the consumer to accept products from a simplified range with the accompanying benefit of better delivery and lower price." It was a practice also "for manufacturers to indicate in their catalogs types of products which can be sold 'off the shelf.'"

They noted "deliberate discouragement by price differentials of the 'special' order." Some companies computed the price of a special order through "systematic separate and complete costing while in other plants special orders were actually produced in separate shops" and that the special orders carried the full overhead charge. In other cases the price addition was an arbitrary one based on experience and judgment. To promote sales volume on a relatively narrow range of types, retail establishments often used advertising pressure to promote consumer acceptance.

In answer to the charge that mass production often results in a lowering of quality, the study team found no evidence to support the allegation. "On the contrary," they said, "we believe that quantity production, properly planned and competently executed, provides assured and consistent quality."

Production Control and Research

The competitive and cost-conscious climate of American industry, the British study notes, was reflected in the lengthy and detailed study devoted to production planning, performance, and control. In most of the plants visited British investigators found "the layout was excellent and every detail of the process had

been studied to secure maximum output of the plant and labor force with minimum of effort." At several factories they were shown "extensive and well-equipped sections devoted to research work and to the application of resultant benefits to the production process." They were "particularly struck by the extent to which effort is directed toward the early and widespread application on a production scale of new knowledge gained from fundamental research work."

How far American industry had advanced in the last three decades is apparent when the commendatory tone of the British investigators is compared with the inefficient practices reported by American study of 1921. This report stressed that "the lack of adequate methods of production control was evident in every industry studied," and that "the lack of effective planning and administration in one large typical plant wasted one fifth of the worker's time." It noted that "at least 10 hours per week per man were thrown away on energy-wasting and time-wasting work resulting from lack of shop methods, while an additional two or three hours per week per man were wasted in unnecessary work." The 1921 report also noted that there was a need for more intensive research activity in every industry. Referring to the clothing industry the report asserted that there was not a single individual in the entire industry who was solely engaged in research.

The main body of the report discussed the various trade and professional organizations contributing to standardization and simplification in American industry and cited a number of examples of how productivity was increased and costs reduced by use of improved methods and the concentration on a limited number of products in any one plant.

Conclusions

The report concludes with the observation that British industry can benefit from longer runs, increased mechanization, simpler operation, more effective use of capital investment, and concentration of sales and advertising effort. It recommends to British trade associations studies to reveal possibilities of simplification and increased effort to publicize the benefits of simplification.

To British manufacturers the report recommends a close study of their own production processes; action to reduce unnecessary variety; endeavor to steer consumer demand toward standard products; and closer collaboration with outside specialized production facilities to make utmost use of long-run low-cost capacity.

To the technical press the report recommends that the subject of high productivity and low cost be given prominent and persistent publicity.

Copies of the report may be obtained free from Economic Cooperation Administration, Technical Assistance, New York Field Office, 2 Park Avenue, Suite 1221, New York 16, N. Y.

Professional Unity at the Grass Roots

THE grass roots of the engineering profession lie not so much in the local sections of national engineering societies as they do in the engineering-college campuses where students first come in actual contact with the organized engineering profession.

This point was made by James F. Fairman, president of The American Institute of Electrical Engineers, in his article "Professional Unity at the Grass Roots," published in the December issue of *Electrical Engineering*.

The engineering profession, he said, had a tremendous opportunity to foster professional unity at the grass roots by working with the engineering students. By its attitude as individuals and as organizations, engineers could indicate that engineering was more than technology, that it was a profession, particularly one profession in spite of appearances to the contrary.

Single Student-Engineering Society

To promote unity of the profession Mr. Fairman suggested establishment of a single student-engineering society at each engineering school with the existing student branches as technical divisions of the student society. "Let us encourage membership in the student society among freshmen and sophomores as well as among juniors and seniors," he continued. "Let us continue to offer student memberships in our national organizations for nominal dues to any student who desires it for the purpose of obtaining the publications of one or more of the societies. Let us accept for the next higher grade of membership in a national organization without admission or transfer fee within a reasonable time after graduation, any student who was a member of the student-engineering society whether or not he was a student member of one of the national societies."

While such a student organization would suffice for recruiting purposes, the main job facing engineers, Mr. Fairman suggested, was that of "helping the faculties give the student a better understanding of what it means to be a member of a profession."

Summer Employment for Students

To help create this understanding among students, the great need was for support by engineers as individuals. Practicing engineers should volunteer to speak before students on all aspects of engineering practice. They should invite them to visit their plants, where outside the academic walls students would be particularly receptive to a glimpse of how engineers work in industry. Mr. Fairman also suggested that engineers should encourage summer employment of engineering students. But the student should not be given a routine job and forgotten, he cautioned. Rather, he should be taken in charge by an older engineer who could discuss with him, preferably after dinner in the engineer's home, all sorts of problems—technical, economic, and political.

"In all of this effort," Mr. Fairman stated, "the emphasis should be on the oneness of the profession," on the problems, the methods of attack, and the processes of analysis which all engineers have in common.

Joint Conference Planned by British Engineers

THREE of the leading engineering societies of Great Britain, The Institution of Civil Engineers, The Institution of Mechanical Engineers, and The Institution of Electrical Engineers, are planning a Joint Engineering Conference to be held in London, June 4-15, 1951. The conference will coincide with the Festival of Britain and will call attention to the interdependence of all branches of engineering. The theme will be "The Achievements of British Engineers." Still in the planning stage, the program will take up the future trends of developing the great power sources in nature and the development of the system of education of engineers in Great Britain.

EJC Seeks National Water Policy

TO DEVELOP action which could ultimately lead to a comprehensive national water policy, the Engineers Joint Council at its meeting in November, 1949, reconstituted its Temporary Committee on a National Water Policy as a Panel on National Water Policy and authorized it to contact key members of Congress to arrange for legislation creating a National Commission or other competent and authoritative group to study control and utilization of one of the nation's greatest national resources.

This action stemmed from the January, 1949, report of the Temporary Committee which called attention to the waste of natural water resources caused by confusion over division of responsibility between public and private interests, and recommended among other things that the organized engineering profession through the offices of the EJC "espouse the organization and prosecution of a project that will yield recommendations for a national water policy."

The EJC Exploratory Committee recommended that the study be pursued under the joint auspices of the engineering profession and the National Research Council. Further discussion, however, developed that the NRC, while greatly interested in the undertaking, could not aid in the accomplishment of the full objectives proposed by the EJC because of certain policy limitations. A further review of the EJC National Water Policy Report indicated that if engineering recommendations were to be effectively used by Congress, a request for such recommendations in the first instance should come from Congress.

What the EJC Panel will seek is "highest use of water for the best economy of the nation in compliance with local and state rights and interests." This objective, the Panel feels, cannot be obtained "without the guidance of clearly defined policies, principles, and procedures based on data established by factual examination of water resources and of existing procedures and principles for their development and control."

To attain its objectives the Panel will confer with committees of other national bodies

interested in a national water policy and arrange for joint or concurrent action in the interest of creation of a Congressional national commission on water policy.

Water-Resources Commission Appointed by President

MORRIS L. COOKE, Fellow ASME, consulting engineer of Philadelphia, Pa., was appointed recently by President Truman to head a temporary seven-man Water Resources Commission to study the problems of federal participation in water-resources projects and to recommend a national water policy.

Other members of the commission are: Leland D. Olds, New York, N. Y.; R. R. Renne, president, Montana State College, Bozeman, Mont.; Lewis W. Jones, president, University of Arkansas, Fayetteville, Ark.; Gilbert White, president, Haverford College, Haverford, Pa.; Samuel B. Morris, Department of Water and Power, Los Angeles, Calif.; and Paul S. Burgess, dean, College of Agriculture, University of Arizona, Tucson, Ariz.

In an executive order setting up the commission, Mr. Truman said:

"The commission shall give consideration in particular to (*a*) the extent and character of Federal Government participation in major water-resources programs, (*b*) an appraisal of the priority of water-resources programs, (*c*) criteria and standards for evaluating the feasibility of water-resources projects, and (*d*) desirable legislation or changes in existing legislation relating to the development, utilization, and conservation of water resources."

In his letter to Mr. Cooke the President wrote:

"The Federal Government already has a substantial investment in existing water-resources improvements; in recent years we have been adding to this investment at a rate of more than $1,000,000,000 annually." An account of EJC actions in the interest of a national water policy appears elsewhere on this page.

Registration Fees

MOUNTING costs of engineering meetings are responsible for the growing practice among the Founder Societies (ASCE, AIME, ASME, and AIEE) to charge members a registration fee at annual meetings.

The American Institute of Mining and Metallurgical Engineers was the first to take this step, when in 1947 a registration fee of $5 for members and $10 for nonmembers was charged to help defray heavy expenses of the AIME 75th anniversary celebrations. The following year the member fee was reduced to $3. AIME members have accepted the practice as a legitimate one in the face of rising costs.

The American Institute of Electrical Engineers introduced the fees last year and continued the practice for its 1950 winter meeting. The American Society of Civil Engineers charged members $1 in 1948, and, at its recent meeting in Washington, increased the fee to $2. Nonmembers at ASCE meetings are not asked to pay a fee.

While The American Society of Mechanical Engineers has instituted member-registration fees for certain of its Divisional Conferences, no such fee has yet been charged in connection with an Annual Meeting. A registration fee for nonmembers has been imposed by ASME for several years.

In support of the fees is a general feeling that members who attend meetings and who thereby benefit directly from these events should be asked to pay more to support them than the member who is unable to participate.

Licensing Among Chemical Engineers

RECOGNITION of engineering as a profession is making slow but steady progress toward a position comparable to that of law and medicine, according to John M. Weiss, head of John M. Weiss and Company, consulting engineering firm of New York, N. Y.

Speaking before a special session on the licensing of chemical engineers at the 42nd annual meeting of the American Institute of Chemical Engineers recently, Dr. Weiss revealed the results of a recent poll of Institute members on the question of professional licensing.

Every state and territory has laws regulating the practice of engineering. Such laws have been in effect in New York for more than 20 years.

With about 20 per cent of the Institute membership participating in the poll, nearly 50 per cent of the active members replied that they were licensed engineers and more than 70 per cent of the junior members possess the sanction of a state license.

The advantages of securing a licensed status were pointed out and discussed. In New York, for example, civil-service positions involving engineering practice can be filled only by licensed engineers. Civil courts will not hear expert testimony on engineering matters unless the witness is a registered and licensed engineer.

Should an unlicensed engineer take court action to recover fees for professional service, his cause would be dismissed without a hearing. Unauthorized use of the term "engineer" in telephone directories or in advertising material can be prosecuted in courts.

The New York state income-tax laws provide exemptions for members of professions, and licensed engineers are included in the exempt classification. Under the Taft-Hartley Act, professional employees, such as engineers, have the right to form negotiating organizations and can restrict the membership of such organizations to professionals if desired.

Many employers are requiring certain members of their engineering staffs to apply for licenses. If, for example, a fatal accident should occur through a faulty engineering design, an unregistered man who made such faulty design could be prosecuted for manslaughter, whereas a registered engineer under the same circumstances is merely guilty of an error in professional judgment. Dr. Weiss added that "the various manifestations of professional recognition of engineers are individually small, but the results are cumulative and steadily increasing."

Massachusetts Engineers Vote to Sustain Permissive Registration Law

MASSACHUSETTS was among the last group of states to adopt an engineering-registration law. Ten years ago, a Committee on Public Affairs of the Engineering Societies of New England, comprising representatives of constituent societies throughout Massachusetts, carried on a careful study of the engineering-registration movement and submitted a report that received thorough discussion on a state-wide basis.

As a result of this survey, the engineering societies of the State united to obtain enactment of a permissive law based upon the Model Law endorsed by many national professional organizations and carrying the recommended standard qualifications for licensure. It was realized at the time the law was proposed that most other states had adopted the mandatory form, but in view of the fact that no evidence was found indicating that all engineers should be compelled to register in order to protect the public and since many engineers objected to the compulsory features, the establishment of engineering registration on a voluntary basis in Massachusetts seemed appropriate.

For the greater part of the first decade after its enactment, the law caused relatively little comment. Its administration was in the hands of a board of five members, all known to be engineers of high competence with notable records of service to the profession and to the community. There was general agreement that the law was serving the purpose well and that it was being ably administered.

Arguments for Mandatory Provision

Recently, however, some Massachusetts engineers have advocated changing the law to make it mandatory, arguing that:

1 It would enhance the professional status of the engineer to require registration as a prerequisite for practice.

2 It would serve to define the profession of engineering and to eliminate confusion in this respect.

3 It would provide a means with legal force for the elevation of the qualifications of an engineer.

4 It would eventually eliminate unqualified pretenders in the engineering field.

5 It would give greater protection of life, health, and property through improving the qualifications of engineers and placing upon them a legal responsibility.

6 Public protection through the statutory

technical code is ineffective and that the most effective protection can be obtained through carefully screened practitioners.

7 Country-wide uniformity of registration laws of professional practice would be promoted since 46 states have some form of mandatory law.

8 There need be no fear of diluting the profession with unqualified practitioners by virtue of a Grandfather Clause since a substantial proportion of practicing engineers in Massachusetts are now registered and since a clause affecting current practitioners could be written into a mandatory law in such manner as not to undo the work of screening so far accomplished by the Registration Board.

During 1948–1949 there was widespread discussion among engineering societies throughout Massachusetts regarding the relative advantages of the permissive type of registration law that has been in effect in the Commonwealth since 1941 and the mandatory form which is on the statute books of most other states. A bill proposing to amend the present Massachusetts statute making it mandatory and introducing other minor modifications of the law was filed in the legislature last year and discussion was focused upon its provisions. Because of the differences of opinion that were voiced among engineers throughout the Commonwealth, the bill was withdrawn by its sponsors in the spring of 1949 with the understanding that a state-wide referendum would be held in the fall to find out what view was held by the majority of engineers.

Joint Referendum Agreed Upon

The referendum was sponsored jointly by ESNE and the Massachusetts Society of Professional Engineers and was administered cooperatively by the Committee on Legislative Affairs of MSPE and the Committee on Public Affairs of ESNE. A ballot was prepared summarizing the arguments for and against mandatory engineering registration and providing an opportunity for the voter to indicate whether he favored or opposed the mandatory type of law for Massachusetts.

Ballots were mailed to an unduplicated mailing list of 10,200 names comprising all registered professional engineers in the Commonwealth, all members of the Massachusetts Society of Professional Engineers, all Massachusetts members of the Engineering Societies of New England, all members of the Worcester Engineering Society, the Engineering Society of Western Massachusetts, and the Pittsfield Section of AIEE.

By the deadline date at noon on Nov. 30, 1949, 4261 ballots (about 42 per cent) had been returned. Of these, 1829 favored the mandatory law, 2355 were opposed to such a law, and 77 ballots were invalid. Thus a majority of 526 engineers who participated in the referendum prefer the permissive law now on the statute books.

An analysis of the vote of various engineering groups follows. Inasmuch as many of those who voted were members of several groups, the vote by societies does not add up to the total of 4184 valid individual ballots that were cast because many votes were counted more than once in the breakdown by branches of engineering.

VOTE FOR AND AGAINST MANDATORY PROVISION

Group	For	Against
Registered Professional Engineers (Mass.)	1120	834
Mass. Society of Professional Engineers	229	76
Eng'g. Society of Western Mass.	35	85
Worcester Engineering Society	37	91
American Institute of Electrical Engineers (Mass.)	353	498
The American Society of Mechanical Engineers (Mass.)	237	364
American Society of Civil Engineers	166	157
Boston Society of Civil Engineers	172	183
American Institute of Chemical Engineers	26	91
American Institute of Mining & Metallurgical Engineers	7	48
American Society of Tool Engineers (Boston and Worcester)	58	183
American Society of Heating and Ventilating Engineers	40	44
American Society of Refrigerating Engineers	27	54
Institute of Radio Engineers	66	310
American Welding Society	25	23
Illuminating Engineering Society	36	68
Mass. State Engineers Association	59	46
Plant Engineers Club	3	20
Boston Society for Quality Control	25	37
Municipal Technical Engineers Association	23	7
Instrument Society of America	20	25
American Society of Lubrication Engineers	2	12
American Society for Non-Destructive Testing	0	8
American Society of Safety Engineers.	19	32

Arguments presented by those who oppose making the law mandatory in which the majority of engineers who participated in the referendum concurred, were as follows:

1 Compulsory registration is an unnecessary and unwarranted infringement upon freedom of engineering practice.

2 The public health and safety are not in jeopardy from engineering practice at the present time; there is no evidence of impending danger; and present statutory codes give adequate protection.

3 It is not possible to legislate a profession into existence and improvement of professional status can and should be achieved by engineers themselves—not by legal pressure from an agency of government.

4 Regardless of what may be proposed with respect to current practitioners the legislature would likely insist upon the customary Grandfather's Clause which would reduce the significance of the title "Registered Professional Engineer" and undo the work accomplished by the Board of Registration over the past nine years.

5 The present permissive law is no impediment to the achievement of a desirable uniformity among state registration laws since it is the qualifications for registration that are here significant and these can be the same whether the law is voluntary or compulsory.

6 A mandatory law would be more difficult to administer, more likely to provoke controversies, and more susceptible to political interference.

Permissive Law Adequate

Another factor that undoubtedly influenced the voting was the unanimous opinion of the four members of the Board who had served continuously since 1941 that the permissive law was adequately serving the need for engineering registration in Massachusetts and that the proposed change to a compulsory form was both unnecessary and undesirable. Mindful of the long and faithful, though unrewarded, service rendered by their representatives on the Board, and of the intimate opportunity these men had had not only to observe the law in operation but also to evaluate its effectiveness, many engineers marked their ballots against the mandatory proposal as a vote of confidence in the members of the Board of Engineering Registration.

In any event, the issue of mandatory versus permissive engineering registration has been decided in Massachusetts in true democratic fashion on the basis of full and free discussion, state-wide referendum, and acceptance of the will of the majority. This clears the docket of a much mooted question upon which Massachusetts engineers differ strongly in their opinions and opens the door for consideration of other matters of mutual concern that are important to the enhancement of engineering as a profession and upon which there is much greater agreement as to ways and means.

Reported by CARROLL A. FAREWELL, president, Engineering Societies of New England, Inc.

Welding-Patent Index Completed

A NEW patent classification index has been completed by the A. F. Davis Welding Library of The Ohio State University. The index is designed to make information on more than 12,000 U. S. patents on welding more easily available to industry and educational institutions.

Each patent in the library is classified or indexed in several different ways—by process, material, product, use, inventor's name, date of issue, etc., on a single keysort card. These cards are sorted mechanically, and in little time the numbers of patents pertaining to a given field may be determined.

Interested industrial organizations then may order those patent specifications from the patent office and refer to the material covered. The patent specifications are on file in the Davis Library and may be consulted by anyone making a search in person.

The use of the patent classification system is offered to industrial organizations, individuals, and educational institutions. Services are free of charge to those who make use of the index system in person, but modest charges will be made for inquiries handled by mail.

United Engineering Trustees Report for 1948–1949

Summary of Facts Concerning Finances, Building, Engineering Societies Library and Engineering Foundation

THE Annual Report of the United Engineering Trustees, Inc., for 1948–1949 was issued on Oct. 27, 1949, by Edward C. Meagher, president UET. Mr. Meagher's report in abridged form follows:

Forty-Fifth Year

In the activities of United Engineering Trustees, Inc., for the past year, here reported, the Board of Trustees has, as always, been mindful that it is a creature of the Founder Societies, created to execute their joint interests, and to act for the Societies in "the advancement of the engineering arts and sciences in all their branches and to maintain a free public engineering library." Although we may not have been called upon by the Societies to operate for them to the fullest extent contemplated by the Societies in formulating our Charter, we believe our willingness to serve to the utmost is understood by them as it is by us.

Engineering Societies Building

The forty-two-year-old building structure continues generally in sound physical condition, except for windows and inadequate elevators. New seats are needed in the auditorium and fifth-floor meeting halls. Its inadequacy for present needs of the Societies, however, is more obvious every day. The ASME occupies more than 3000 square feet in an adjoining building, and AIEE editorial department is housed three blocks away.

Occupancy of meeting halls has been reduced greatly through application of recent city rulings on public assembly places. We have been required to enclose all exit stairs, virtually creating inside fire towers. This has been done skillfully by our consulting architects without great disfigurement of the splendid marble staircases and lobby. The cost has been held to a minimum, and was much less than in many similar buildings. It has been paid from a reserve wisely established several years ago through the foresight of Arthur Tuttle.

Further space changes resulted from the reduction of meeting-hall space, closing room 503 to meetings, and forming two offices which were immediately taken up at a rental assessment which offsets the loss of meeting-hall revenue.

New Public Address System

During the year the public-address system in both auditorium and fifth-floor halls, was completely replaced, to the expressed satisfaction of the halls' users.

Building service employees received another advance in wages this spring through the operation of the mediation board.

We need new chairs for the fifth-floor meeting halls, new seats in the auditorium, new windows and frames throughout the building, and the elevators are approaching the stage when replacement will be a consideration.

Financial Matters

Most of the activity in investing during the year has been due to call or maturity of issues held. Our Finance Committee met several times with our financial advisers for the purpose of reviewing our portfolio and considering the market and policies.

The usual addition of $20,000 was made to the Depreciation Reserve, which together with $27,433.74 interest, brings the year-end total value of this fund to $711,692.27.

There is also a General Reserve which was authorized in 1914 at $10,000, which has been drawn upon from time to time to help over strained periods. It has been for several years, $5383.66, but this year has been increased to the authorized amount against need.

At the end of our fiscal year, the aggregate book value of the Combined Fund was $1,960,882.58 with a market value on or about that date of $2,050,179.35 or 104½ per cent of the book value. This percentage for the previous year was 103½ per cent.

The Corporation continues to act as treasurer for Engineers' Council for Professional Development, and as custodian of the funds of the John Fritz Medal Board of Award and the Daniel Guggenheim Medal Board of Award, and of monies from outside sources contributed for the support of research projects sponsored by the Engineering Foundation.

By-Laws

Our By-law Committee studied conditions and prepared new by-laws governing the Engineering Societies Library, which were enacted during the year. The personnel of the Library Board was reduced and meetings called monthly, thereby making a working board which operates the Library, instead of a policy board as previously.

Our Committee recommended a study of Engineering Foundation. This study is still in progress and no report can be made at this time on by-laws governing the Foundation. Editorial changes remain to be made on other by-laws, which will be undertaken after the more important changes are enacted.

The Engineering Societies Library

IN his annual report to the Library Board, Ralph H. Phelps, director, Engineering Societies Library, New York, N. Y., stated:

The thirty-sixth library year, 1948–1949, has been one of study, analysis, and change. The survey by Mr. Wood was primarily a study of library services, but it gave some consideration to collection and space problems. It led to the development of a new photoprint service. Much material has been discarded. New shelving has been installed. For the first time in several years the Library ended the year with a credit balance. These and other developments and activities of the year are reported more fully below.

New Photoprint Service

A survey authorized by the Library Board and financed by a $5000 grant by The Engineering Foundation, was made by Richardson Wood. The Library Study Committee, under the chairmanship of Ole Singstad, supervised the survey. Of the three recommendations of the report, the one regarding the extension of the Library's photoprint service appeared to be the most practical, so it has been modified and adopted for a trial period. For many years the Library has supplied photoprint copies of material in its own collection. It will continue this service. It will now also supply a photoprint copy of any engineering or technical article that is available anywhere in this country, whether or not it is in the Engineering Societies Library. This service has been announced and its promotion begun.

Use of the Library

Current business conditions are reflected in the following figures that show a reduction in the number of paid services, but some increase in the number of persons visiting the Library.

	1947–1948	1948–1949
Visitors served ... total	22,228	22,921
Nonvisitors served ... total	17,442	15,908
Total	39,670	38,829
Photostat orders	4,135	3,986
Photostat prints	49,954	47,377
Microfilm orders	141	174
Searches and paid services	141	139
Translations	49	61
Words translated	212,288	126,005
Borrowers	2,200	1,687
Books lent	3,011	2,343
Telephone inquiries	7,263	6,606
Letters written (exclusive of book orders)	3,513	3,255

Financial Changes

During the year the Founder Societies agreed to make their allotments to the Library, on the basis of their membership, three months instead of fifteen months before the beginning of the fiscal year. This change provided an unanticipated increase in income of over $2200. Contributions from other organizations, and income from sale of books and periodicals were over $1300 greater than anticipated. Expenditures were less than anticipated, largely because two staff members who resigned were not replaced. For the first time in several years, costs of operation did not rise faster than income. The Library ended the year with a small credit balance.

Miscellaneous Activities

The staff prepared brief reviews of 514 books valued at over $2600. These reviews are published in the journals of the four Founder Societies, in the Journal of the Engineering Institute of Canada, and by the Engineering Index.

The director was appointed by the Engineers' Council for Professional Development as its representative on the Advisory Com-

mittee of the United States Quarterly Booklist, issued by the Library of Congress. He participated, at UNESCO'S invitation and expense, in the International Conference on Science Abstracting, held in Paris in June, 1949. He continues as the representative of the ASCE and the ASME in the American Documentation Institute, and also as chairman of the Engineering Societies Monographs Committee. Since the Monographs series started in 1931, the Library has received over $6500 in royalities.

Acquisitions and Cataloging

The Library has a good collection, partly because it receives so many gifts. Of all material received by purchase and gift, there were 7162 items that were worth checking against present holdings. An even greater number were discarded without checking as they were obviously of no value. From the 7162 items 4926 were selected for addition to the collection. Of these, two thirds were either outright gifts or were given for review.

The 4926 selected items consisted of 1765 volumes, 708 maps, 58 searches, and 2395 pamphlets. The latter were inserted in volumes already counted and therefore do not add to the total number of volumes. After allowance for the withdrawal of 409 volumes and 3 maps, the net accessions as of Sept. 30, 1949, amounted to 167,826 volumes, 11,219 maps, and 5114 searches—a total of 184,159 items.

As in the past, the Library has received many valuable gifts of books and magazines from various individuals. Also technical societies, publishers, and other organizations have given generously of their own publications and other publications that have come to them. Sydney H. Ball bequeathed to the Library his valuable and complete collection of books on precious stones. There are some 400 volumes dating from 1548.

The Engineering Foundation

IN their annual report to the United Engineering Trustees, Inc., Joel D. Justin, chairman, and Frank T. Sisco, technical director, of The Engineering Foundation, stated:

During this fiscal year, the Foundation sponsored and supported 14 research projects, of which eight received from industry and other interested organizations financial support that was far in excess of that received from the Foundation.

When the current year ended on Sept. 30, 1949, Engineering Foundation completed 35 years of service to the engineering professions, and to the four engineering societies for which the Foundation is the joint research instrumentality. It is fitting, therefore, that the annual report for 1948–1949, as printed for general circulation, pay some attention to the part played by the Foundation in stimulating engineering research and in advancing the engineering professions since the 25-year report of progress was prepared by Director Hovey in 1939.

The Role of the Foundation

Engineers who are familiar with the history of the Foundation are unanimous in affirming that much essential research work would never have been done, and that much valuable engineering data would never have become available, if it had not been for the foresight of the Foundation in visualizing the need for this research and in supplying the initiative and encouragement necessary to start the project and carry it through to a successful conclusion. Continually over the years, the early sponsorship and the small grants of money by the Foundation have been vital to the organization of a project and have stimulated the interest of industry and others sufficiently so that funds have been forthcoming for its successful completion.

What is not so generally realized is how important the catalytic effect of the Foundation really is, and how this effect is increasing. Table 1 summarizes the role of the Foundation in stimulating engineering research and in advancing the engineering professions, since it was established in 1914.

TABLE 1

	Engineering Research, 60 projects	Advancement of Engineering Professions, 23 projects
Funds contributed by Engineering Foundation	$ 571,000	$ 148,000
Funds contributed by industry and others	7,818,000	857,000
Total	$8,389,000	$1,005,000
Amount of Foundation assistance, per cent	6.7	15.0

Co-Operation With NRC

In May, the technical director was invited to attend a meeting of the National Research Council's Division of Engineering and Industrial Research and as a result the National Academy of Sciences, parent body of National Research Council, formally invited the Foundation to be represented on the Council's Engineering Division. This invitation was accepted by the Foundation Board, and the technical director was named as representative for the interim term ending Sept. 30, 1949.

The Foundation was closely associated with, and contributed generously to, the Council in its formative years during the first world war, and a renewal of cordial and close relations between these two important organizations opens the way for increased co-operation in research and greater benefits to the engineering professions.

Summary of 1948–1949 Projects

During the fiscal year just ended, the Foundation sponsored and made grants toward the support of fourteen projects; twelve of these were in engineering research, and two—Engineers' Council for Professional Development, and the Survey of the Engineering Societies Library—were primarily for the advancement of the engineering professions.

From its available funds the Foundation contributed $42,500 for these projects, and industry and others contributed, in cash and services, approximately $443,000. Foundation support for these projects on a dollar basis was 9.5 cents, and other support amounted to 91.5 cents.

The following research projects supported by the Foundation are those in which the ASME is particularly interested:

Lubrication (Project 23)

Chairman, B. L. Newkirk, department of aeronautical engineering, Rensselaer Polytechnic Institute, Troy, N. Y.

This project has been of interest to The American Society of Mechanical Engineers since 1923, and was occasionally sponsored and financially aided by The Engineering Foundation during the first 12 years of its existence. In 1946, the ASME Research Committee on Lubrication, in considering ways and means to continue the project, decided that a thorough review of available data was urgently needed. This would provide a background in laying out a future research program and also make available pertinent data to engineers confronted with lubrication problems, and to producers of lubricants. The literature survey has been completed, and as the result an important program of research has been worked out and started at Harvard University in 1948: it is to continue for two years. Foundation sponsorship and a grant of $3000 were requested for the fiscal year 1948–1949, and these were approved.

The over-all goal of the present project is to extend knowledge of the pressure-viscosity characteristics of lubricants with special reference to their performance in machines. Most of the measurements will be made at pressures up to 150,000 psi although in some cases these may be extended to 450,000 psi. Test temperatures will run from 32 to 425 F, and attention will be paid to the effect of shear stresses and shear rates. Lubricants will be carefully and systematically selected.

During the current fiscal year experimental equipment was completed and a large volume of data was obtained, at temperatures ranging from 32 to 425 F and at pressures up to 10,000 atmospheres for many petroleum-base and synthetic lubricants. The equipment has been calibrated against Bureau of Standards standard samples and a deviation of test-reproducibility of less than three per cent is being obtained. This calibration, together with the data on compressibility (already complete on four samples) and density, will permit translation of time-of-fall observations obtained in the falling-body type of viscosimeter into kinematic and absolute viscosity units.

An industry advisory board has been established and has met twice to supply close industry guidance in the selection of specimens and on the project as a whole. Co-operation and cross-checking of the results with a somewhat similar project of the American Petroleum Institute is being maintained, and several oils used for this project are being tested in machine elements by the co-ordinating Research Council. The co-operation of the petroleum and synthetic-lubricant industries has been outstanding in the preparation of samples and in furnishing chemical and physical test data.

Plastic Flow of Metals (Project 68)

Chairman, A. Nadai, Research Laboratories, Westinghouse Electric Corporation, East Pittsburgh, Pa.

In 1934 a research project sponsored by ASME was established at University of Pittsburgh and Westinghouse Research Laboratories to study the plastic flow of metals—a phenomenon that enters into all mechanical working of metals and alloys, but about which little fundamental knowledge is available. Engineering Foundation aided this project for two years with small grants; and during the time the work was going on it became clearly evident that a major effort would be necessary to solve even a few of the problems in this important field. Accordingly, in 1936, ASME appointed a special research committee on plastic flow, and the present project was established. Since 1936, work has been going on almost continuously on the rolling of metals at Massachusetts Institute of Technology, and for part of the time on the flow of strip through circular tools at Case Institute of Technology.

The object of the work at MIT is to measure the normal and shearing stresses in the contact area between rolls under a wide range of rolling conditions (including varying percentages of reduction and different temperatures and speeds) and to investigate the effect of these variables on the properties of the material. It is planned to determine for the first time the complete contact stresses under controlled rolling conditions and the effect of these stresses on the finished product.

The project at Case Institute of Technology has as its object the investigation of the rolling of strip through tools, and the results should be applicable to such commercial operations as strip rolling in tension, tube drawing, and the production of deep-drawn shells. It is hoped that the results of this investigation will explain a number of difficulties now encountered in commercial operations; for example, the decrease in gripping power by changing the type of roll drive, the loosening of shell bottles from mandrels, and a number of others. Included in this project is a theoretical and experimental analysis of the strains encountered in sinking and reducing tubes; if successful, this should permit prediction of the initial wall thickness necessary for a definite final wall thickness, which must now be determined by trial and error or by a final machining operation.

Elaborate and complex experimental equipment and measuring devices are necessary to determine contact stresses under controlled rolling conditions, and much time and effort have been spent at MIT in designing and constructing the special rolls, contact-stress measuring devices, torque meters, and others that are necessary. Special difficulties have been encountered in determining longitudinal and transverse contact shearing stresses owing to the entry of the rolled material into the clearance between the weighbar tip and the roll. In the last year a new weighbar was designed, which functions with a minimum clearance in the diametral hole in the surface of the role, thus eliminating errors in normal stress caused by material that flows up and around the weighbar tip. The weighbar, torque meter, and other equipment have been calibrated, and test runs will start shortly.

Specimens are being machined from copper, aluminum, and low-carbon steel, and strength in tension and compression, yield point in tension and homogeneous compression, impact strength, directional properties, and metallographic structure will be determined both before and after the rolling tests. In addition, it is expected that in the next two or three months an adequate solution to the shearing-stress difficulties will have been effected and that considerable normal stress data will have been accumulated.

About a year ago Prof. William Baldwin took over the work at Case Institute of Technology, after the resignation of Prof. George Sachs. Based on theoretical studies by Sachs, equipment has been constructed for the measurement of draw stresses and pressures during drawing operations with various combinations of undriven and stationary circular dies. The first of a series of such tests was made by drawing annealed 70–30 brass strip through idling rolls. Reductions ranged from 10 to 45 per cent in a single pass. Draw stresses and pressures were measured for each, and a series of tensile tests were made to determine the flow stress of each strip after drawing. All of the experimental work on this particular investigation has been completed, and an analysis of the data is now under way.

Properties of Gases (Project 91)

Chairman, J. A. Goff, dean, Towne Scientific School, University of Pennsylvania, Philadelphia, Pa.

This project is still in its formative stage. It was organized in 1947 after an extensive survey covering industrial companies active in the fields of power, refrigeration, chemical processing, and transportation had shown that there is definite dissatisfaction with present knowledge regarding the thermodynamic properties of even the common gases such as oxygen, nitrogen, argon, hydrogen, helium, carbon monoxide, carbon dioxide, water vapor, etc. This survey also disclosed substantial interest in the thermodynamic properties of a large list of refrigerants, hydrocarbons, propellent gases, dissociation products, etc., which heretofore have not been subject to systematic investigation. Also, attention was called to the almost complete lack of reliable information regarding the thermodynamic properties of gas mixtures. Finally, this survey revealed that a knowledge of the so-called nonthermodynamic properties, such as viscosity, thermal conductivity, diffusivity, and emissivity, is also urgently needed.

The committee in charge of the project has worked out a program which is being used as the basis for solicitation of funds from industry. This program includes: (1) The experimental determination of viscosity and thermal conductivity of the common gases in the high-temperature, high-pressure range to meet industrial requirements; (2) the experimental determination of thermal conductivity of gases at low pressures to aid in developing a working theory; and (3) the assembly and critical analysis of existing data, development of skeleton tables with recommended tolerances and the like on an international scale. In connection with this third phase of the program there has already been an interchange with Great Britain of information on low-temperature properties of common gases aimed at the development of such tables.

Engineering Foundation made a grant of $1000 to this project in 1947, which has been used for the exploratory work and for the formulation of a research program.

Group Named to Study Declassification Of AEC Technological Reports

A WORKING party of representatives of technical and engineering societies and business press has been selected by the Atomic Energy Commission and is expected soon to begin to examine declassifiable technological information in the field of metallurgy with a view to determining its possible value to American industry.

Members of the working party have been given a complete security investigation and clearance to enable them to enter restricted areas and to examine restricted information files. The first meeting of the working party will be held shortly after the first of the year, at which time it will confer with AEC staff members and establish methods for carrying on its program.

Members of the working party are: Keith Henney, consulting editor, *Nucleonics and Electronics*, and representative of the Institute of Radio Engineers; S. A. Tucker, The American Society of Mechanical Engineers; F. J. Van Antwerpen, editor, *Chemical Engineering Progress*, American Institute of Chemical Engineers; Sidney Kirkpatrick, vice-president, McGraw-Hill Book Company, editor, *Chemical Engineering;* and E. E. Thum, American Society for Metals, editor, *Metals Progress*.

Establishment of the working group is the second step in a trial program set up by AEC in response to the recommendation of its Industrial Advisory Group that information still classified, but potentially declassifiable and of special interest to industry, should be surveyed and declassified.

The first step of this program was taken with the appointment of a temporary advisory committee which met with AEC officials in September. At that time the advisory committee approved the general plan for the test program as proposed by AEC and nominated the members of the working party in the field of metallurgy.

The initial task before the working group will be to examine the abstract file maintained by the AEC Patent Branch. This file contains

abstracts of technical subject matter on all novel, practical, and patentable processes and equipment developed in the atomic-energy program. From selected groups of abstracts the working group will decide which subject matter appears to be of interest to American industry generally, and complete reports of such subjects will be made available to the group for further consideration.

Abundance of Engineering Opportunities Predicted

ENGINEERS need have no fears about the drying away of opportunities for engineering employment in the future according to T. A. Boyd, research consultant, General Motors Research Laboratories, who presented recently an optimistic picture to student engineers of Princeton University.

Mr. Boyd supported his optimism by three observations: (1) Men of the older generations will continue to pass on responsibility to younger men; (2) a continuing expansion of industrial activity; and (3) a standard of living in the United States which depends on technical talent for its maintenance and betterment.

"Industrial research as a business," he said, "has grown more than twenty-five-fold during the period of my activity in it, until now it gives employment to about as many persons as the nation's lawyers and doctors combined."

He pointed out that in his company alone "the total workers in various activities . . . under engineering and research is large enough so that the annual expenditure in those departments now is about 60 million dollars."

The nation's living standard, particularly in the present century, has increased the demand for technical talent which is expected to continue upward during the next half-century, the speaker explained.

He alluded to the recent Brookings Institution analysis which predicted that 100 years from now "the nation may well have progressed to the point where it can support a population double that of the present and on a plane of living eight times as high as that now prevailing."

"To attain and to maintain any such standard," Mr. Boyd declared, "is naturally going to require the services of a great many engineers and other technical men. For it is only through the services of men trained in technology that little by little such a high goal could be approached."

Employers of technical personnel, he said, are looking for men who can master the round-up of scattered information and bring it to bear upon a particular problem. "This demands the ability to think independently," he added.

"Progressive employers do not want the man who thinks that all knowledge has already been obtained and written down in handbooks.

They are looking for the man who is good at getting new knowledge. This means that he must know and be able to use the so-called scientific method, the method of observation and experiment, which is the basis of all research."

An Engineer in Atlanta

ONE of the needs of the engineering profession, a dramatization in popular literature of the engineer at work and how he contributes to the life and comfort of the community, is gradually winning the attention of free-lance writers.

In the December 3, 1949, issue of *The Saturday Evening Post*, Tom Mahoney, free-lance writer, in his article, "The Store that Married a City" gives an account of how Frank Neely, Mem. ASME, and a graduate of the Georgia Institute of Technology, applied engineering ideas to the management of Rich's Incorporated, Atlanta, Ga., and helped to build the enterprise into one of the finest retail establishments in the South.

Mr. Neely came to Rich's in 1924 after more than ten years of practice in scientific management devoted mainly to the application of Taylor's system in industries employing largely women. His achievements as the engineer in charge of operating functions of the Fulton Bag and Cotton Mills, with factories in several cities including Atlanta, so impressed Walter Rich, owner of the store, that he made Mr. Neely a fabulous offer for his services.

Disciple of Taylor and Gantt

Since then Rich's management has been dominated by a bold and imaginative conception of what a retail establishment should be in a community. In telling his story, Mr. Mahoney devotes much of his space to Mr. Neely's career and to how his influence gradually dominated not only the employees of the store but reached out to every new resident who came to Atlanta.

As a disciple of Taylor and Gantt, Mr. Neely introduced a system of checks and balances which allows buyers to purchase efficiently and accurately and made it possible for customers who want to make an adjustment, or who have a complaint, to state their wishes to the clerk in the proper department and to have them granted without having to seek out the bureau of adjustments or the complaint department.

Under his leadership the store expanded into a second building and the original one was redesigned to incorporate efficient merchandising ideas. A conveyer system was installed to deliver crates from the railway cars to the marking room and another to deliver outgoing packages to the delivery trucks. The system was also extended to the cars of customers in the store's shoppers' garage. Customers who turn in parking tickets after making a purchase, find their packages in their cars when they drive away.

Influenced Store's Public Relations

But more than the techniques of management, what appeals to Mr. Mahoney is Mr. Neely's influence on the store's public relations. Under his guidance the store has identified itself as a social force in the community. The store cashes checks when the banks are closed. In the depression of the 1930's it paid the salaries of Atlanta's teachers by cashing script issued by the city. Its staff assists with weddings and aids customers in plans for entertainment. After the tragic Winecoff Hotel fire in 1946, the store's staff visited survivors and relatives and offered all needed clothing. Its executives serve on civic committees and contribute generously to local colleges.

FRANK NEELY, MEM. ASME

Explaining Mr. Neely's success in the department-store business, his colleagues acknowledge Frank Neely as more than a great engineer. He has the ability, they say, to apply the "coldly scientific methods in such a way that they require happy and interested human beings to make them work best. Neely has always been more of a teacher than an engineer anyhow."

If the end of engineering is to simplify methods and techniques until these are concealed by their own simplicity, this is high tribute.

Tribute to ASME Publication

THE *Journal of Applied Mechanics*, published quarterly by The American Society of Mechanical Engineers, was used as the index of what is being contributed to new knowledge in mechanics by Dr. Walter Ramberg, chief, Mechanics Department, National Bureau of Standards, Washington, D. C., in his article, "Contributions of Electricity to Mechanics," published in the September 15, 1949, issue of *Journal of Washington Academy of Science*.

Referring to the ASME publication as "the leading American journal in the field of applied mechanics," Dr. Ramberg reported on a study of authors published by the *Journal* in 1946 and 1947. He found that of the 77 papers published during those two years, the authors of 28 were listed in *Who's Who in Engineering* for 1948 and in *American Men of Science* for 1944. Only 29 per cent of the 28 papers came from authors with an orthodox training in mechanical engineering, 16 per cent came from authors with a major training in electrical engineering,

and the remaining from authors with a physics and mathematics background. Because electricity is one of the major subjects in the mechanical-engineering curriculum and the strong probability that many of the physicists elected electricity as their major, it was his contention that electricity is making a substantial contribution to the advancement of mechanics.

Dr. Ramberg is a member of the ASME.

Meetings of Other Societies

Feb. 23

National Industrial Conference Board, Inc., Waldorf-Astoria Hotel, New York, N. Y.

Feb. 26–March 1

American Institute of Chemical Engineers, regional meeting, Hotel Rice, Houston, Texas

Feb. 27–March 3

American Society for Testing Materials, committee week and spring meeting, Hotel William Penn, Pittsburgh, Pa.

March 14–16

Society of Automotive Engineers, Inc., national passenger-car, body, and production meeting, Hotel Book-Cadillac, Detroit, Mich.

March 28–31

Greater New York Safety Council, 20th annual safety convention and exposition, Hotels Statler and Governor Clinton, New York, N. Y.

April 3–4

Association of Iron and Steel Engineering, spring conference, Hotel Tutwiler, Birmingham, Ala.

April 3–5

American Management Association, production meeting, Hotel Statler, New York, N. Y.

April 4–7

National Association of Corrosion Engineers, annual conference, Hotel Jefferson, St. Louis, Mo.

April 10–14

American Society of Tool Engineers, tool engineers industrial exposition, Convention Hall, Philadelphia, Pa.

April 16–18

American Society of Lubrication Engineers, 6th annual convention and 4th annual lubrication show, Bellevue-Stratford Hotel, Philadelphia, Pa.

(For ASME Calendar of Coming Events see page 192)

Scientific Management in Norwegian Schools

NORWEGIAN newspapers and radio stations are co-operating in a project to make the Norwegian people aware of what scientific management can do to promote efficiency and eliminate waste. The project is being sponsored by the Department of Education of the Norwegian Government in accordance with plans prepared by the School Committee of the Norwegian National Committee of CIOS (International Committee of Scientific Management). Since February, 1949, Norwegian schools from the sixth grade on have been exposed to scientific-management ideas.

The project was initiated by the Norwegian National Committee when it was realized that young people who were entering professional schools had little or no knowledge of the meaning of scientific management. To make boys and girls aware of the cost of materials, the necessity of avoiding waste, and the possibilities of reducing costs, the Committee suggested rewording problems in mathematics to reveal the principles of scientific management. For example, the problem of determining how many circular areas were contained in a given rectangle was reworded to require the determination of the waste of material when a given number of disks were cut from a given rectangle.

But beyond this simple and casual method of instilling the spirit of efficiency in the lower schools, the Committee is urging that professional and technical schools make scientific management a special subject of teaching.

Supplementing the Government program, the Committee has provided a list of qualified speakers to lecture at meetings and conferences of teachers to win their interest and understanding and to give them the information needed. The National Committee has also approached printers and editors of school books to obtain necessary additions and alterations to the next issues to carry on the program of indoctrination.

Smoke-Abatement Group Notes Progress

THE demand for the solution of the air-pollution problem which confronts most of our larger cities has now happily passed the stage of wishful thinking," H. B. Lammers, Mem. ASME, chairman of the Coal Producers Committee for Smoke Abatement, recently told the annual meeting of that organization in Cincinnati. Representatives of 21 producers and consumers of coal were present.

"When the Coal Producers Committee for Smoke Abatement was organized nine years ago nearly everyone assumed that all pollution in the cities came from products of combustion and especially from the combustion of coal," Mr. Lammers recalled. "This assumption has been disproved so many times that now no one conversant with the problem places any credence in it whatever.

"As a matter of fact, the really tough part of air-pollution work comes after most of the smoke has been eliminated. Industrial fumes and processes add considerably more to the smogs and air pollution over our cities than does the burning of coal.

Henry F. Hebley Mem. ASME, director of Research for the Pittsburgh Consolidation Coal Company, reviewed the report on the Donora, Pa., smog incident in 1948, which was prepared by the U. S. Public Health Survey. "Despite a year's research by many scientists the survey was unable to find conclusive evidence as to what air pollutants were responsible," Hebley said. "It is known that a temperature inversion—an atmospheric condition in which the air above the earth is warmer than that at ground level—actually put a lid over the Donora valley and held in all the pollutants for days, but thus far the researchers have not decided just what caused the deaths during the smog."

Mr. Hebley said that during the year he attended symposiums on air pollution held by three national scientific societies and in "none of them did I hear the word smoke mentioned. This is proof to me," he said, "that the men who really understand the magnitude of this problem are convinced that smoke is a very small contributing factor."

Notes on Coming Meetings

Materials Handling

A MATERIALS-Handling Conference will be held at Purdue University, West Lafayette, Ind., Feb. 20–21, 1950. Papers to be presented will cover such subjects as statistical approach to materials handling, how materials-handling costs are determined, and efficiencies effected by materials handling.

For additional information or copies of the program write to Merle M. McClure, Technical Extension Division, Purdue University, West Lafayette, Ind.

Electric Railways

THE Traction Technical Committee of The Institution of Electrical Engineers, London, is sponsoring a convention on electric-railway traction to be held in The Institution Building, London, from March 20–23, 1950.

Latest views and practices in electric-railway traction will be discussed in a technical program consisting of an opening lecture and 30 papers.

History of Science

THE Sixth International Congress for the History of Science will be held at Amsterdam University, Amsterdam, Netherlands, Aug. 14–20, 1950, under the auspices of the Academy and the International Union for the History of Science, and organized by the Netherlands branch of the union.

Apart from general and committee meetings, the congress members will meet in four sections: History of mathematics, physics, and astronomy; history of chemistry, pharmacy,

and biology; history of applied science and technology; and history of medicine.

Electric Welding

THE second Conference on Electric Welding to be sponsored by the American Institute of Electrical Engineers in co-operation with the American Welding Society and the Industrial Electrical Engineers Society of Detroit, will be held in Detroit, Mich., April 5–7, 1950. The program will be designed to carry on the discussion and report on further progress in electric-welding fields since the first conference in Detroit in 1948.

Both arc and resistance-welding processes will be covered by technical sessions as well as stud welding, submerged arc welding, power-supply problems, and other topics. An unusual feature of the program will be practical demonstrations of the techniques and equipment covered by technical papers.

British Industries Fair

THE British Industries Fair is expected to be the biggest and best "shop window" ever displayed. Three thousand manufacturers representing 26 groups of allied trades and 90 industries, will occupy 358,000 square feet in London and Birmingham, from May 8–19, 1950, and record numbers of overseas buyers are expected. At the last fair held in 1949, over 17,000 buyers attended. As a national trade fair, only manufacturers whose goods are produced within the United Kingdom will exhibit. A Commonwealth section will include representative displays organized by Commonwealth governments.

Education

ADOPTION of two new five-year education programs by the Lehigh University faculty, effective immediately, was announced recently.

The first five-year curriculum will offer the degree of bachelor of science in mechanical engineering at the end of four years and that of bachelor of science in electrical engineering at the end of the fifth year.

The second new curriculum approved will give a student the opportunity to receive the degree of bachelor of science in industrial engineering at the end of four years and that of bachelor of science in business administration at the end of the fifth year.

* * *

INDUSTRIAL grants in aid totaling $800,000 to the Massachusetts Institute of Technology were announced recently by Dr. James R. Killian, Jr., president of the Institute. The grants bring total gifts to the Institute in its current development program to $6,526,914.02.

Grants announced included $250,000 from the United Fruit Company of Boston; $50,000 from an unnamed Massachusetts Corporation; $250,000 from the Cities Service Research and Development Company of New York; and $250,000 from the Standard Oil Company of California.

A NUMBER of fellowships and research assistantships are being offered by the Plastics Laboratory, Princeton University, suited to mechanical-engineering graduates interested in advance training in plastics. For further information write to Louis F. Rahm, director, Plastics Laboratory, 30 Charlton Street, Princeton, N. J.

Engineering Literature

German Motorcars

A SURVEY of the German motorcar industry during the period 1939–1948 has been published as Report 21 of the British Intelligence Objectives Subcommittee.

The 82-page booklet is based on reports of British and American observers written just after termination of hostilities. It reports on the general regimentation under which the industry operated under the Nazi government and describes construction details of German motorcars. The report also includes a special section on German racing-car development between the years 1934 and 1939.

Commenting on German trade secrets the uncovering of which was one of the objectives of the survey, the report states that none were found.

"The drain of mental energy to develop tanks and artillery, the flying bomb, V-2's, jet engines, rocket craft, naval craft, submarines, etc., had presumably left little excess ingenuity even in that most ingenious nation," the report states.

The report can be obtained from the British Information Services, 30 Rockefeller Plaza, New York 20, N. Y. Price is 50 cents.

Oil-Engine Power Costs

THE REPORT on "Oil-Engine Power Cost for 1948" has just been published by The American Society of Mechanical Engineers. Prepared by the ASME Oil and Gas Power Division, the report covers a survey on cost and performance data of 441 engines operating in 124 plants whose total output in 1948 was over 700 million kwhr.

Included in the report are such significant data as: type of plants and load; number of engines; total capacity; hours of operation; gross and net output; annual point-load factors; and others. Important data on engine and plant operating costs are also given. A summary of maintenance and fuel costs of Diesel locomotives is included as a supplement to the report.

Copies of the report may be obtained from ASME Publications Sales Department, 29 West 39th Street, New York 18, N. Y. Price is $2.50.

Materials Handling

BIBLIOGRAPHY on pallets used in modern materials handling, which lists 114 books and periodical articles published from 1937 to date, was published recently by the Engineering Societies Library, New York, N. Y. The publication "ESL Bibliography No. 4" covers all aspects of the subject of pallets, including the design and construction of the different types, the handling of various materials on pallets, the savings achieved in materials handling, and details of present-day applications in individual plants in a large number of industries.

Copies may be purchased from the Engineering Societies Library, 29 West 39th Street, New York 18, N. Y. Price is $2.

Economic Research

A comprehensive review of current business and economic research carried on in American colleges and universities was issued recently by the Department of Commerce as part of its program to increase the usefulness of university research activities.

The volume, "Survey of University Business and Economic Research Projects, 1947–1948," lists 1188 research projects in 105 colleges and universities covering 24 subject fields, including Government-business relations, labor relations, management, marketing, public finance, and international trade.

Copies may be obtained from the Superintendent of Documents, Washington 25, D. C., at $1 each.

People

HENRY BUTLER ALLEN, Mem. ASME, executive vice-president and secretary of The Franklin Institute, Philadelphia, Pa., was granted an honorary doctor-of-engineering degree by Drexel Institute of Technology, at the commencement convocation held in the auditorium of the school, Dec. 13, 1949, in conjunction with Drexel's annual observance of Founder's Day. The honor was conferred on Dr. Allen in recognition of his "contributions to the progress of science, to the advancement of technical education, and to the promotion of the public welfare."

* * *

THE AMERICAN Standards Association announced election of three new members of its board of directors effective Jan. 1, 1950, for a term of three years. Maurice Stanley, chairman of the board of the Fafnir Bearing Company, represents the Anti-Friction Bearing Manufacturers Association, Inc.; B. S. Voorhees, vice-president of the New York Central System, represents the Association of American Railroads; and Col. J. G. Vincent, Mem. ASME, vice-president of the Packard Motor Car Company, represents the Automobile Manufacturers Association.

Continuing on the board for another three-year term are J. H. McElhinney, vice-president of the Wheeling Steel Corporation, representing the American Iron and Steel Institute, and Auguste G. Pratt, chairman of the board of Babcock & Wilcox Company, representing The American Society of Mechanical Engineers. R. Oakley Kennedy, formerly vice-president of Cluett, Peabody and Company, Inc., has been re-elected member at large for the next three years.

ASME NEWS

Washington, D. C., to Be Scene of 1950 ASME Spring Meeting

FOR the first time since 1930 when The American Society of Mechanical Engineers celebrated its 50th anniversary in Washington, D. C., the Society is looking forward to a national meeting in the nation's capitol. The occasion will be the 1950 Spring Meeting to be held April 12 to 14, at the Statler Hotel, for which the ASME Washington, D. C., Section is working up a technical program of more than usual interest. With the National Government a heavy investor in scientific and industrial research and the large number of scientific laboratories situated in the Washington vicinity, the meeting provides an excellent opportunity to visit these research institutions.

Technical Program

The technical program will consist of 20 sessions sponsored by the following divisions and committees: Aviation, Fuels, Gas Turbine Power, Heat Transfer, Industrial Instruments and Regulators, Machine Design, Management, Oil and Gas Power, Power, Process Industries, Wood Industries, American Rocket Society, Education, Cutting Fluids, Lubrication, and Safety.

A feature of the program will be a symposium on turbojet anti-icing. Admittance to this session will be restricted to those persons who have obtained advance clearance for it. Members interested in the subject are urged to write to James W. Wheeler, Mail Station 2Q38, Sperry Gyroscope Company, Great Neck, N. Y., for a security questionnaire. The questionnaire must be filled out and returned to Mr. Wheeler well in advance of the meeting.

The Education Committee is planning a program on postcollegiate education which should be of interest to young engineers. The session will include papers on training for career development, developing professional competence in industry, and training for transition to professional responsibility.

The tentative program will be published in the March issue of MECHANICAL ENGINEERING.

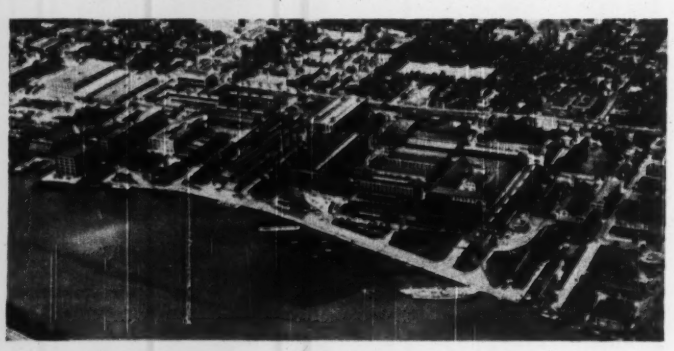
Plant-Inspection Trips

Each day of the meeting arrangements have been made to take ASME groups through many of the scientific laboratories and research centers in and around Washington. On Wednesday parties will leave for the Naval Ordnance Laboratory and the Potomac River Generating Station. On Thursday inspection trips are scheduled to the David Taylor Model Basin, Bureau of Standards, and the Timber Engineering Laboratory. On Friday ASME groups will visit the U. S. Naval Academy and the U. S. Naval Experimental Station.

The Statler Hotel will serve as headquarters hotel for the meeting. The prices in Washington range as follows: Single room, $5 to $11.50; double room with large double bed, $8 to $12; double room with twin beds, $9.50 to $14.50. For accommodations in the Statler Hotel, members should write to Mr. George Lumbard, Front Office Manager, Statler Hotel, Washington, D. C., prior to March 28, 1950.

Women's Program

An interesting women's program is being arranged for wives and guests of members. The program includes luncheons and a tea, sight-seeing trips to historical points of interest, a guided tour through the Capitol Building, and the Mellon and Freer Art Galleries. On Friday there will be a sight-seeing trip to the Naval Academy at Annapolis, Md.



U. S. NAVAL GUN FACTORY, ONE OF THE POINTS OF INTEREST IN WASHINGTON, D. C., WHERE THE 1950 ASME SPRING MEETING IS TO BE HELD APRIL 12–14

Committees

The following members are in charge of the arrangements for the Spring Meeting: Rudolph Michel, general chairman; Harry P. Harwood, vice-chairman; Mrs. Ralph Goetzenberger, ladies chairman; W. G. Allen, finance; Charles Shreeve, Jr., technical events; C. C. Vogt, printing and signs; Charles E. Greeley, entertainment; Ralph Goetzenberger, reception; Charles Berberich, publicity; H. H. Snelling, information and registration; Benjamin C. Cruickshanks, trips; Francis M. Thuney, hotel; F. H. Kohloss, students.

Nominations Sought for ASME 1950 Awards

ALL members or agencies of the Society such as Committees, Sections, and Professional Divisions, are encouraged to submit nominations for the various awards on or before March 1 of each year. Each nomination should be supported by the following: (1) Full statement of the training, experience, and notable contribution of the nominee; (2) statement of the basic reasons for submitting the nomination and for believing the nominee is eligible for the honor; (3) other information or reference which will assist the Board on Honors in considering the nominee.

It is absolutely essential that such nomination carry the present title and company connection of the candidate, or if he is retired, his present residence address.

Those wishing to make a nomination should first obtain a copy of a Manual on ASME Honors and Awards. This may be had by writing to the Secretary, ASME, 29 West 39th Street, New York 18, N. Y.

Awards for 1950

Honorary Memberships: Five may be awarded each year. The Constitution provides the recipients shall be persons of "professional eminence." These awards are not limited to Society members. A nominee must be endorsed by 25 members of the Society.

ASME Medal: This award is made for distinguished service in engineering and science, and may be conferred in recognition of general service in science having possible application in engineering.

Holley Medal: The award is made for some "great or unique act of genius of an engineering nature that has accomplished a great and timely public benefit."

Worcester Reed Warner Medal: This award is made to honor the author of an outstanding contribution to permanent engineering literature. Permanent engineering literature may be a book, a series of books, a single paper, or a series of papers, which have been recognized as important additions to engineering literature by the profession.

Spirit of St. Louis Medal: Awarded at approximately three-year periods for meritorious service in the advancement of aeronautics.

AIR VIEW OF ST. LOUIS, MO., WHERE THE 1950 ASME SEMI-ANNUAL MEETING IS TO BE HELD JUNE 19–23

1950 Semi-Annual Meeting to Be Held In St. Louis, Mo., June 19–23

ST. LOUIS, MO., the "Gateway to the West," will be the scene of the 1950 Semi-Annual Meeting of The American Society of Mechanical Engineers to be held in the Statler Hotel, June 19–23, 1950. Arrangements are already under way for a program of 31 technical sessions and a number of social events and inspection trips which will convince many members that their 1950 vacations should be taken in June and should include a visit to St. Louis.

Eighth Largest City

As the eighth largest city in the United States, St. Louis is an industrial center of much interest for the mechanical engineer. There are plants to be visited which produce all types and classes of ferrous and nonferrous products, steel mills, railway-car building plants, electric-motor and transformer manufacturers, Diesel-engine and heavy-machinery manufacturers, bottle and glassmaking industries, ammunition and powder plants, flour mills and elevators, shoe factories, oil refineries, and many other activities. This is a highly diversified area with no one industry overshadowing the others.

Supplying the facilities for this industrial activity are the steam and hydro plants of the Union Electric Company, the gas plants of the Laclede Gas Light Company, the Mississippi River Fuel Company's natural-gas pipe-line facilities, the great water-purification plants of the city, the railroad and terminal facilities of all major freight and passenger lines, as well as airport and airline services.

For the accommodation of visitors, the Statler Hotel will serve as headquarters for the out-of-town guests and for all committee meetings, technical sessions, and social events. The St. Louis Statler is centrally located and from its doors all parts of the city and area can be easily reached.

It will not be all work and no play for members who attend the Semi-Annual Meeting in St. Louis. The Municipal Opera will be open and will be a "must" for ASME visitors. This beautiful open-air theater presents a brilliant and colorful spectacle. The lead parts are played by the finest talent of the American stage, the dance and singing choruses are trained to perfection, and the large orchestra is manned by the finest musicians. A night at one of these light-opera performances will be remembered a long time.

Then of course there will also be major-league baseball games, the famous St. Louis Zoo, parks, museums, botanical gardens, and just about anything needed for a pleasant vacation.

Technical Program

The following professional divisions and ASME committees are planning sessions: Aviation, Applied Mechanics, Fuels, Gas Turbine Power, Heat Transfer, Hydraulics, Machine Design, Management, Materials Handling, Petroleum, Power, Process Industries, Production Engineering, Railroad, Education, Boiler Feedwater Studies, Cutting Fluids, and Furnace Performance Factors.

Committees

In charge of local arrangements for the Meeting are the following: General Committee, J. C. Parmely, chairman; R. W. Merkle, vice-chairman; J. J. Sieber, secretary; R. O. Slattery, treasurer; G. V. Williamson, technical events; L. W. Morrell, inspection trips; W. J. Woodruff, registration; A. J. Leussler, entertainment; C. B. Briscoe, hotel; C. H. Rulfs, printing and signs; R. M. Boyles, publicity; R. R. Tucker, reception; David Larkin, finance; Mrs. John K. Bryan, ladies' events; A. L. Heintze, transportation.

Outside Photographers

IT is not the custom of The American Society of Mechanical Engineers, either at its meetings or conferences, to engage the services of outside photographers to take pictures of groups or individuals. All photographic work is done by the ASME staff, except in cases where members of the local press are invited to cover a special function. Be guided by this information to avoid embarrassment in the future.

Standard for Cutters Aim of Wood Industries Division

THE Wood Industries Division of The American Society of Mechanical Engineers recently mailed a questionnaire to leading manufacturers to determine their interest in a standard for arbor dimensions of woodworking machinery. Partial returns indicate a definite interest in this proposal.

The project is sponsored by the Wood Industries Subcommittee on Wood-Cutting Tools and Equipment and is the first step by the ASME to end confusion caused by the great variety of arbor dimensions used in connection with circular saws and cutters in the wood industry.

The questionnaire asks for information on catalog designations of woodworking machinery using arbors. Data requested include arbor diameters, arbor speeds, diameters of saws accommodated, and saw gages.

If final tabulation of responses indicates a general interest in standardization in this field, the Wood Industries Division will request the ASME Standardization Committee to initiate action for formation of a "sectional committee" under the procedures of the American Standards Association, Inc. The procedures of the ASA assure every organization having a substantial interest in the project of an ample opportunity for participating in the work of such a sectional committee.

Thomas D. Perry, temporary chairman of the subcommittee, welcomes inquiries from interested companies and individuals. His address is 301 East Main Street, Moorestown, N. J.

Petroleum Division Creates New Committees

THE Petroleum Division of The American Society of Mechanical Engineers recently announced the creation of three new committees and two additional committee posts in its program for increased service to the engineers in the petroleum industry.

The committees are: Membership Development Committee, F. J. Daasch, Gulf Oil Corporation, Tulsa, Okla., chairman; Students and Recent Graduates Committee, Linn Helander, Kansas State College, Manhattan, Kan., chairman; Advisory Committee, William Raisch, consulting engineer, Long Island City, N. Y., chairman.

The new posts are that of Publicity Secretary to which O. L. Lewis, Jones and Laughlin

Supply Company, Tulsa, Okla., was named, and Research Secretary to which E. N. Kemler, Southwest Research Institute, Houston, Tex., was appointed.

The Petroleum Division is one of the newest of the ASME Professional Divisions and has been doing excellent work in promoting the mechanical aspects of the petroleum industry. Its annual conferences staged in the Southwest have won the support of the industry.

E. W. Jacobson of Gulf Research and Development Company, Pittsburgh, Pa., is 1950 chairman, and J. N. Sexton of M. W. Kellogg Company, New York, N. Y., is serving as secretary of the Division.

1950 RAC Meetings Announced

BETWEEN March 20 and May 6, 1950, all Sections of The American Society of Mechanical Engineers will send delegates to eight Regional Administrative Committee Meetings, one in each of the ASME Regions, to discuss regional and national problems, as well as to consider and act upon items submitted by various Sections. This material is compiled by the Agenda Committee.

The meetings held in the spring of each year are part of the machinery by which individual members through the Officers of their Sections can have their say about how the Society conducts its activities. A list of the meetings appears elsewhere on this page.

In the fall of each year the ASME Agenda Committee invites each Section to suggest topics for discussion for the next Conference. These items are tabulated by the Agenda Committee and sent to each of the ASME Sections for approval. Items approved by 15 or more Sections are placed on the final agenda for consideration by the Regional Administrative Committees. Items approved by a majority of the RAC meetings are then placed in the agenda of the Regional Delegates Conference. Each delegate to these meetings and the Conference receives a mileage and per diem allowance from the National Society toward his expenses. Two delegates from each Section attend the Regional Administrative Committee Meetings, at which two delegates from each Region are selected to carry actions of that Region to the Regional Delegates Conference held at the time of the Semi-Annual Meeting. The actions of this Conference are referred to Council for final disposition.

Four-Day Conference Planned by ASME Pittsburgh Section

THE 1950 national conference of the ASME Process Industries Division is being held on April 24–27, 1950, jointly with the annual Mechanical-Engineering Conference of the Pittsburgh Section of the ASME. As is customary, the latter is being sponsored by the Pittsburgh Section with the active co-operation of the following Societies: American Materials Handling Society, Pittsburgh Chapter; Engineers Society of Western Pennsylvania, Mechanical Section; and Society for the Advancement of Management, Pittsburgh Chapter.

Because of the joint sponsorship of the conference, the program has been designed to interest all process engineers while emphasizing process industries of the Pittsburgh area. It should therefore have both national and local appeal. Inspection trips of two nearby industries planned to give members more than a superficial glance at operations, as well as the technical sessions, may well attract engineers from other Sections.

Not forgetting student members, the Planning Committee has arranged to have seniors of local engineering schools present papers at each of the technical sessions on a subject allied to the one under discussion during the session. As an incentive to attend the conference, students will be given reduced rates for banquet tickets.

Technical Program

The first technical sessions on Monday morning, April 24, will be sponsored by the ASME Process Industries Division and will be devoted to "Conditioned Air for Blast Furnaces." A student from Carnegie Institute of Technology will present a paper pertaining to blast furnaces.

The formal opening of the Conference will be a luncheon on Monday to which members will be welcomed by A. M. G. Moody, chairman of the Pittsburgh Section, and by a representative of the Process Industries Division.

Two sessions will be held Monday afternoon. The first will be a dust-collection symposium sponsored by the mechanical division of the ESWP. Seven speakers representing leading manufacturers will speak on applications of electrostatic precipitators, operation and maintenance of cloth filter-type dust collectors, unsolved dust-collection problems and others. At the second session Crosby Field, Fellow ASME, will talk on "Small Ice." On Monday evening one session will be devoted to the design of chemical-process equipment and the other sponsored by the Process Industries Division will discuss "Treatment of Waste Pickle Liquors" and "The Process and Use of Perlite."

Two sessions are planned for Tuesday morning. The first will be devoted to synthetic fuels and the second to methods time measurement. On Tuesday afternoon the Lake Erie-Ohio River conveyer will be discussed by two speakers associated with the project. The second session will take up the problem of installation, operation, and maintenance of low-cost oxygen plants in the steel industry.

The high light of the conference will be the banquet scheduled for Tuesday evening. President James D. Cunningham has been invited to address the gathering.

The third-day sessions will be devoted to metalworking, radiant heating, and spray drying.

Inspection Trips

At 11:30 on Wednesday morning arrangements have been made for a party to leave for the Babcock and Wilcox Tube Company, Beaver Falls, Pa., for a luncheon at the General Broadhead Hotel, to be followed by a tour of the plant. Guides will conduct the group through the plant which has a capacity of producing 15,000 tons of seamless steel per month. A feature of the trip will be inspection of continuous casting of steel billets, forging of blooms, and methods used to inspect finished tubes.

At 8:30 Thursday morning another trip has been arranged to the Robena Mine of the H. C. Frick Coal Company, Uniontown, Pa. Upon arriving at the mine the group will be conducted to the underground dumping station and will follow the path of the coal through the screening and breaker building, blending bin, washing plant, and river landing tipple.

For the wives and guests of members attending the Conference the Women's Auxiliary of the Pittsburgh Section organized last spring is planning an interesting program of social and sight-seeing events.

1950 Regional Administrative Committee Meetings

Region	City	Hotel	Days	Dates
I	Springfield, Mass.	Highland	Fri–Sat	May 5–6
II	New York, N. Y.	Headquarters	Mon–Wed	March 20–22
III	Baltimore, Md.	Lord Baltimore	Mon–Tues	April 10–11
IV	Greenville, S. C.	Poinsett	Thurs–Sat	April 6–8
V	Akron, Ohio	Mayflower	Mon–Tues	April 17–18
VI	Des Moines, Iowa	Fort Des Moines	Fri–Sat	April 21–22
VII	Los Angeles, Calif.	Mayfair	Thurs–Fri	April 27–28
VIII	Dallas, Texas	Baker	Fri–Sat	March 31–April 1

ASME Junior Forum

COMPILED AND EDITED BY A COMMITTEE OF JUNIOR MEMBERS

The Chairman Reports

BECAUSE of the tremendous number of meetings being held and the multitude of details to be taken care of during an ASME Annual Meeting, the only time I was able to catch Secretary C. E. Davies for a discussion about the junior problems was at breakfast on Thursday morning, December 1. President H. J. Gough of The Institution of Mechanical Engineers also joined us. He was very friendly and seemed quite interested in the problems of junior engineers.

I told Mr. Davies that the National Junior Committee this year was going to take concrete action. Even though the problems and programs with which we deal are intangible, we are convinced that specific action can be taken. Mr. Davies commented that this was an ambitious but quite a worth-while objective.

I went on to explain that the main aims for 1950 will be: (1) To promote programs which will encourage the attendance and participation of more junior members in ASME activities; (2) to encourage junior members to undertake a program of constructive individual growth; and (3) to actively urge junior members to recognize their responsibilities and opportunities as citizens.

Mr. Davies inquired just how we intended to put these aims into action.

I thought they could be implemented in several specific ways: (1) Organizing and sponsoring conferences at national meetings, specifically aimed at the interest of the younger members; (2) publishing the Junior Forum; (3) writing and distributing special pamphlets; (4) preparing a directory of active juniors for use of the committee chairmen and ASME headquarters staff; (5) preparing and distributing a pamphlet on methods of persuading junior members to attend meetings; and (6) carrying on personal correspondence between Junior Committee members and active juniors in other parts of the country.

Mr. Davies agreed that in order to accomplish these objectives it would be necessary to assign specific tasks to individuals throughout the country. He suggested that we increase the size of the committee to ten members, and that one of the members be selected to act as secretary. I concurred wholeheartedly with this suggestion and promised to make specific recommendations from our directory of active juniors before the next meeting of the committee on January 21.

I also suggested that the number of junior advisers on standing committees should be increased to two, on those committees which do not now have two junior advisers. These men, in our opinion, should be ex officio members of the Junior Committee and should serve as a source of information and ideas, both to the Junior Committee and to the younger membership as a whole. The additional younger men for these jobs could be selected from the directory of active junior members.

Encouraged by the fine acceptance of the junior-sponsored session at the Annual Meeting, we are proceeding with plans to sponsor similar meetings at the Spring, Semi-Annual, and Fall Meetings. It is our aim to be able to report some definite progress on each of these meetings soon.

After we had finished our second cup of coffee, Mr. Davies said that we had a fine program outlined and he would be glad to do whatever he could do to help to put this program into effect.

He concluded his comments by stating that he hoped the junior members throughout the country would realize what an outstanding opportunity they had to benefit from participation in this program.

By DONALD E. JAHNCKE, chairman,
National Junior Committee

Needs of Young Engineer Studied by Rochester Section

THE Rochester Section is planning two extra meetings in 1950 to be devoted to the interests of the young engineer. This development has been under consideration for several months to determine if there is sufficient interest to warrant the scheduling of a full program next year. It might be well to point out that the size of the Rochester Section is about 200 members and that a section of this size is considered to be a borderline case as to whether or not a junior group can function successfully as a separate unit. In most cases where the membership is 200 or less the junior interest is served by devoting one or two of the regular monthly meetings to junior members who plan and conduct such meetings. This, however, is not a hard and fast rule and should not be applied without first making a study of the interest which junior members take in regular monthly meetings. In the Rochester Section it seems advisable to carry out separately these first two meetings.

Current Program

The following is a brief review of the 1950 program of the Rochester Section. Meetings are held on the second Thursday of each month at the Hotel Sheraton. These meetings are broad in nature and are designed to cover the interest of the men working in local industries. Such subjects as management and new techniques in engineering are to be presented. Attendance at these meetings represents a cross section of the membership. A second group of meetings is conducted by the Machine Design Committee and is called "A Round Table Discussion of the Machine and Product Design Group." This group meets on the second or third Wednesday of the month. The place of meeting is either the University of Rochester or at one of the industrial plants in Rochester. The subjects discussed by this group are of specific interest to the machine or product designer and are conducted on a technical and informative plane. The attendance here quite naturally represents men in the Society whose interests are in this specific field. Both programs are open to all engineers whether or not they are members of the ASME. Usually the formal programs are held as joint meetings with the Rochester Engineering Society.

New Program

The new program will be devoted to the young engineer rather than the junior engineer, to distinguish between juniors by virtue of age and juniors by virtue of their ASME membership grade. All members of the Rochester Section will be invited to participate. Members of the student branch at the University of Rochester also will be invited.

Instead of organizing a separate Junior Committee, the necessity of which is in question at the moment, this new activity will be carried out by the program chairman who is a member of the executive board. The program chairman is a junior member both in age and grade. In planning for this new activity the program chairman attended the 1949 Annual Meeting in New York, made a survey of several meetings that had to do with the interests of the young engineer, and had a discussion with the chairman of the National Junior Committee. In this manner information for the program was obtained. The following subjects have been considered for the junior meetings: Education after graduation; the engineer and his civic responsibility; why professional registration, integrating the engineer in his community; ASME functions and organization; city-government structure; management training; and opportunities in the field of engineering.

The new program aims to stimulate interests of young men engaged in engineering and to encourage them to take advantage of opportunities for growth available through the

ASME. The intent also is to arouse interests to the point where they become aware of and begin to take on civic responsibility.

By WILLIAM P. WIER, JR., Jun. ASME, Rochester Section

Letter

To the Editor

A MAXIM which I read many years ago by an author that I have since forgotten has stuck in the back of my mind. It reads, "Service is the rent a person pays for his space on earth." While I was listening to Judge Arthur T. Vanderbilt's talk on "Standards for Citizenship" at the 1949 ASME Annual Meeting, this saying came to the forefront and made me wonder whether I was paying as much rent as I should. Or more specifically, was I shirking my duties as a citizen?

Judge Vanderbilt, who is Chief Justice of the Supreme Court of New Jersey, in presenting the first Roy V. Wright Memorial Lecture, brought forth many interesting but, I might add with self-abasement, disturbing points that I would like to mention briefly for the benefit of those who were not present. He first mentioned the lack of interest professional men have in public affairs and illustrated this point by an anecdote revealing that even politically active men and women often could not identify the public officials governing them—even officials as important as their congressman or their own state senator or representative. The question that I came to was: "Could I?"

Judge Vanderbilt further mentioned the neglect in the simplest practice of good citizenship—voting. It is alarming to consider the prediction that the next president will probably be elected from a group of voters that comprise less than 50 per cent of the total eligible voters. Is the task of electing our representatives in government so unimportant that we find it difficult to spend 30 minutes a year in determining who will be the people who govern us?

Have any of us tried to put off jury service by using trumped-up excuses? How many of us have said "no" to the precinct captain when asked to sit on the local election board on election day? How many of us have alibied out of community-activity work when the opportunity to serve was presented us? Are we so naive to think that the government or the community is an automaton that does not need individual effort to make it function? Not everyone can be responsible for a political party's management. Not everyone is employed in work that leaves him the opportunity to run for public office. But the fundamental duties of citizenship along with other activities such as working with youth groups, for example, the YMCA or Boy Scouts, or helping in church affairs, or participating in local engineering-society functions, to mention a few, give everyone the opportunity to pay his share of the rent.

I hope that the inspiration that aroused me while listening to Judge Vanderbilt's lecture will pervade other society members when his paper is published in a future issue of MECHANICAL ENGINEERING. Let's all of us, particularly the younger engineer, make an additional effort to use our professional education to serve our community and government by participating more fully in public affairs.

By JOHN B. BURKHARDT, Jun. ASME

Indexes to Publications Available Upon Request

SEPARATE Indexes for 1949 to MECHANICAL ENGINEERING, the Transactions of the ASME, and the *Journal of Applied Mechanics* are available. The cost of the three indexes is 25 cents. Separately they are ten cents each.

Requests should be made to the ASME Order Department, 29 West 39th Street, New York 18, N. Y.

Instrumentation Courses

THE Education Committee of the Industrial Instruments and Regulators Division of ASME is collecting data on instrumentation and automatic-control courses being taught in engineering schools and colleges. Information on the survey, including course outlines of 26 different courses in 23 engineering schools, may be obtained by writing to Donald P. Eckman, Chairman IIRD-ASME Education Committee, College of Engineering, Cornell University, Ithaca, N. Y.

ASME Elects Twelve Fellows

THE American Society of Mechanical Engineers has honored twelve of its members by electing them to the grade of Fellow of the Society.

To be qualified as a nominee to the grade of Fellow one must be an engineer who has acknowledged engineering attainment, 25 years of active practice in the profession of engineering or teaching of engineering in a school of accepted standing, and has been a member of the Society for 13 years. Promotion to the grade of Fellow is made only on nomination by five Fellows or members of the Society to the Council to be approved by Council.

The men who, by virtue of their contribution to their profession and to the Society, were so honored are:

Howard Stewart Bean

HOWARD S. BEAN, chief of capacity, density and flow-meter section, National Bureau of Standards, Washington, D. C., was born in Santa Clara County, Calif., Oct. 23, 1893. He received the degree of BSME in 1917 from the University of California. Since 1922 Mr. Bean has been a leader in the development of orifice meters for measuring the rate of flow of both gases and liquids. Much of his work has been the determination of the numerical factors upon which the Reynolds number depends. The methods and data, for which he is to a great extent responsible, are of basic importance in the steam, oil, and gas industries. As chairman of the Subcommittee on Revision of Report, Part 1, ASME Research Committee on Fluid Meters, he prepared the text and edited the fourth edition, 1937, of Fluid Meters: Their Theory and Application. He has made considerable contribution to the literature in the technical field and holds a patent on shock-absorbing landing gear.

Hobart Cutler Dickinson

HOBART CUTLER DICKINSON, chief of the Heat and Power Division, National Bureau of Standards, Washington, D. C., until his retirement in 1945, was born in Bangor, Maine, Oct. 11, 1875, and died Nov. 27, 1949. He was educated at Williams College and received an AB degree in 1900 and an MA, 1902; in 1910 a PhD from Clark University. Dr. Dickinson's achievements include the following: The Altitude Laboratory, the first laboratory for testing aircraft engines under the conditions of low-temperature and low barometric pressure which simulated flight conditions; the bomb calorimeter for measuring the heat of combustion of fuel; such as coal, oil, etc.; Standard Values for Ice and Water—by measuring the specific heats of ice and water and the heat of fusion, of ice, basic data for refrigeration engineers was obtained. These values are the standards today for ice and water. In connection with these measurements, important developments were made in calorimeters for making such measurements. These improved calorimeters have been widely used in investigations of the properties of other substances which are of great importance to mechanical engineers. International Standards—as a representative of the Society on International Committees on steam tables and heat units, he was instrumental in assisting the committees to reach satisfactory decisions by his assistance. His papers in scientific and technical publications have been many and of importance. He was a member of societies both here and abroad which concerned themselves with the advancement of science and engineering. (For obituary see page 198).

Hugh Latimer Dryden

HUGH L. DRYDEN, director of research, National Advisory Committee for Aeronautics, born in Pocomoke City, Md., July 2, 1898, was educated at Johns Hopkins University. In 1916 he was granted an AB; 1918, AM; and 1919, PhD. Dr. Dryden is an authority on the subject of laminar and turbulent flow, particularly near surfaces in the region known as the boundary layer. He was responsible for the development of instruments for measuring turbulence, the most important being the hot-wire anemometer and the pressure sphere. His work on turbulence, both theoretical and experimental, pointed out the importance of turbulence as an aerodynamic variable and

showed that turbulence in wind tunnels was responsible for the conflicting results obtained with streamlined bodies and wings in different wind tunnels. This made possible the interpretation of wind-tunnel tests and contributed greatly to the improvement of airplanes. Improved wind tunnels, in turn, made it possible to reproduce flight conditions and greatly facilitated the study of laminar-flow airplane wings.

During the recent war, Dr. Dryden was vice-chairman of the Committee on Aerodynamics of the National Advisory Committee for Aeronautics, chairman of the NACA Committee on self-propelled guided missiles, and chief of the Division of New Missiles of the National Defense Research Committee. He was director of the development of guided missiles, notably the radar-controlled glide bomb, the Navy "Bat," which when released from the mother airplane homed automatically on its target. For his war work on guided missiles he was awarded the Medal of Freedom. He is a member of many military and scientific groups which work in this field and has served as a member of the Publications Committee of the ASME. He was president of the Washington Academy of Sciences in 1948.

Paul Burn Eaton

PAUL BURN EATON, professor and head of the mechanical-engineering department, Lafayette College, Easton, Pa., started there as assistant professor in 1924. He had taught at Cornell University and The Pennsylvania State College before. From 1915 to 1918 he had been professor of mechanical engineering and head of the department at the Chinese Government Engineering College, Tangshan, China.

He has served the U. S. Government as consultant in industrial training, engineering, science, management, defense, and war-training divisions. He was consultant to the U. S. Department of State on Special Mission to China and was later adviser to the Ministry of Communications of the Government of the Republic of China.

Professor Eaton has written many papers on his experience in China and is the co-author of "Machine Design." He is a member of the "Old Guard;" was a member of the Committee on Relations with Colleges, 1940; manager, 1940–1942; and vice-president, Region III, 1947–1949.

Edward Beach Gallaher

EDWARD B. GALLAHER, industrialist, engineer, and designer, was born in Paris, France, April 28, 1873, and educated at Stevens Institute of Technology. He received an ME degree in 1894. Mr. Gallaher's contributions to the advancement of the science of engineering are numerous and diversified. By use of a process which he discovered about 1889 he pioneered with the *New York World* in making newspaper illustrations directly from photographs. From 1890 to 1900 he was engaged in the design and development of some of the first American-made gas and gasoline-operated engines. Later, as a partner in the Gallaher-Baylis Engineering Company, New York, N. Y., he designed and constructed a number of electric traction and trolley roads, as well as powerhouses for both lighting and trolley service. The firm was retained as consulting engineers for several municipal railroads. At about the same time, he served as consulting engineer for the DeLaVergne Refrigerating Company, New York, N. Y., in the development of the Hornsby Acroid oil engine and the Diesel engine for the Westinghouse Machine Company of East Pittsburgh, Pa., in the development of its first line of gas engines. He also organized the Keystone Motor Company, Philadelphia, Pa., and designed and manufactured what is believed to be the first gasoline-engine-powered horseless carriage manufactured for sale in America. In 1903 he took out a basic patent on a grinding and lapping compound, called "Clover Compound," and incorporated the Clover Manufacturing Company in 1907 at Norwalk, Conn., which today is a tremendous enterprise running into the millions. He began the publication of an economic service in 1910 and today his "Clover Business Letter" and other writings reach over 150,000 people each month. He also writes a monthly economic bulletin for the Army Ordnance Association. Mr. Gallaher was awarded in 1947 the Crowell Gold Medal by the American Ordnance Association and in 1949, a plaque "in recognition of his great contribution to the National Defense of the United States."

Ralph Leon Goetzenberger

RALPH L. GOETZENBERGER, vice-president and director of the Washington Projects Office of both the Minneapolis-Honeywell Regulator Company and Brown Instrument Company, was born in Minneapolis, Minn., Dec. 4, 1891, and educated at the University of Minnesota, receiving a BS degree in 1913 and EE in 1914. After working with various engineering firms as consultant, and his service in the first world war as a major in ordnance, he was engaged by Minneapolis-Honeywell in 1927 to organize the industrial-controls division when the company first became interested in promoting the use of full-automatic controls for industrial processes. Originally, under Mr. Goetzenberger's direction, the company's first line of industrial control motors, valves, etc., was developed. After the acquisition of the Brown Instrument Company, Mr. Goetzenberger was made vice-president of the organization and had under his charge the market-research-development program. The purpose of this division was to further the use of full-automatic controls in industry. He was responsible for and largely directed the efforts of the Moist-O-Graph and the use of instrumentation and automatic controls in the textile industry. At the outbreak of the European war in 1939, he was detached from the Brown Instrument Company and given the assignment of directing the work covering contacts with the various divisions of the Armed Service, directing his particular efforts toward Army Ordnance and Navy. Through Mr. Goetzenberger's efforts, the company played a prominent part in the fire-control instruments program; for example, the redesign and manufacture of practically the entire periscopic fire-control and sighting equipment was necessary. He was active in connection with committee work for the Army Ordnance Association in reference to the supply of optical glass that was to necessary for all fire-control work. He is an advisory member of the EJC Committee of the U. S. National Commission for UNESCO; ECPD delegate on Citizens' Federal Committee for Education, adviser to the U. S. Office of Education; Fellow, AIEE, and a member of several scientific and technical societies.

Arthur Frederick Johnson

ARTHUR F. JOHNSON, professor of mechanical engineering, school of engineering, George Washington University, Washington, D. C., was born in Brooklyn, N. Y., June 27, 1889. In 1911 he received an NA degree, Webb Institute of Naval Architecture; ME, George Washington University, 1915; and PhD, University of Michigan, 1938. Dr. Johnson has been allied with George Washington University since 1916 in various teaching capacities and served as acting dean of engineering from 1930 to 1931. Since 1923 he has been consultant to many government and private undertakings in his field. During the war he was largely identified with the "Seamobile," a unique vessel which had its hulls prefabricated at the steel plants, except for the bow and stern. Hull assembly was done at emergency shipyards with minimum of equipment and skilled labor. The special design of the power plants of these vessels further reduced the delay in construction and the cost. Expensive thrust bearings were replaced by standard rubber truck tires, fitted into vertical tube trunks, further simplified the conventional construction. During the first ten months of "Seamobile" service under charter to a private concern, fuel oil, gasoline, and alcohol were transported coastwise through good and bad weather at profit to the U. S. Government. The results of this undertaking have demonstrated the desirability of such a design, modified according to sea-trial results, for future emergency sea transport.

Dr. Johnson is the author of several books and has contributed papers which have been of much value to the field.

Ralph A. Sherman

RALPH A. SHERMAN, assistant director, Battelle Memorial Institute, Columbus, Ohio, was born in Oskalossa, Iowa, Dec. 18, 1896. He received a BA degree from State University of Iowa, 1920. Mr. Sherman's career with the Bureau of Mines began as an analyst in the coal laboratory, Washington, D. C., then in the fuel section, Pittsburgh, Pa. Later he was made assistant physicist to fuel engineer. He did research work on marine boilers. In 1930 he joined the Battelle Memorial Institute as supervisor, Fuels Division, and did research on combustion and radiation from flames of pulverized coal and natural gas, domestic fuels, domestic stokers, industrial stokers, gasification, pulverizer design, smokeless stoves, and carbonization. In 1947 he was made assistant director of the institute. Mr. Sherman has been responsible for the technical direction of all activities on fuels and mechanical equipment. He holds patents on a stoker, and apparatus for burning carbonaceous fuels, and one burning solid fuel. Some of the papers he has written are: "Supply of Air to Coal-

Fired Steam Locomotives," "Energy Sources of Tomorrow," "Looking Ahead In the Fuels Supply," and "Development of a Design of a Smokeless Stove for Bituminous Coal." He is a director at large of the ASME.

Ludwig Skog

LUDWIG SKOG, senior partner, Sargent and Lundy, Chicago, Ill., was born in Bodo, Norway, March 24, 1888. He received an ME degree from Trondheim Polytechnic Institute in 1909. Mr. Skog is one of the developers of the reheat cycle and cyclone furnace. He received a citation from the government for his work as engineer in charge of design and construction for power development and mechanical process engineering for the Oak Ridge (Tenn.) gaseous-diffusion plant. He is one of the co-authors of the paper, "The Horizontal Cyclone Burner," which was given at the ASME Annual Meeting in 1946. Mr. Skog visited several European countries to study power-plant engineering and on his return he stopped in England to act as consultant to Merz and McLellan, London, in connection with a large power plant erected in London.

John St. Lawrence

JOHN ST. LAWRENCE, retired assistant works manager, Erie Works, General Electric Company, was born in Harlepool, England, Dec. 29, 1880. He received an ME degree from the University of Toronto, 1908. During a period of nearly 34 years with the company he was assistant mechanical superintendent, manufacturing superintendent, general superintendent, and during the last eighteen years assistant works manager. He was responsible for selecting and training a corps of capable assistants. He was also responsible for providing manufacturing engineering direction to his associates, enabling them to design suitable buildings, select equipment, provide facilities, and train an organization to handle more than 15,000 employees as the plant expanded, compared with about 1500 in 1913. Mr. St. Lawrence was authorized to contact Army and Navy procurement officers in an attempt to obtain so-called Educational orders for Army or Navy Ordnance that would be produced on facilities at the Erie Works or by slight additions to existing facilities. The record at the Erie Works in meeting the exacting requirements on $^{5}/_{38}$-in. gun mounts was recognized; Mr. St. Lawrence was called to Washington to receive from James Forestall, Under Secretary of the Navy, the first E-Award made to the General Electric Company. He was also elected to honorary membership in the Navy League.

The Navy's increasing need for destroyers made it necessary for the company to expand operations for the production of destroyer turbines from time to time as the submarine menace increased. G-E finally reached an output of 16 units or 480,000 hp a month. This performance brought several E-Awards and letters of approval from top-bracket officers of the Navy.

As war demands became more urgent new manufacturing facilities of 670,000 sq ft and manufacturing equipment at a cost of approximately $16,000,000 had to be provided. Mr. St. Lawrence was given responsibility for executing this program. The Syracuse turbine plant was built, equipped, and organized in record time—approximately seven months. A total of approximately 3,000,000 hp was produced, finally reaching an output of 28 turbine-generator units a month. The company's contribution to the Navy program and particularly to the destroyer-escort program was recognized by a citation to Mr. St. Lawrence from the Navy Bureau of Ships for "Outstanding Service to the U. S. Navy during World War II," dated March 1, 1947.

Since the termination of the war and until Mr. St. Lawrence's retirement in September, 1947, he was responsible for manufacturing-engineering direction in converting to peace-time production and providing employment for upward of 15,000 people.

Julian B. Tobey

JULIAN B. TOBEY, president, Appalachian Coals, Inc., Cincinnati, Ohio, was born at Freesoil, Mich., Aug. 7, 1895. He was educated at Michigan State College, and in 1918 received an ME degree from the U. S. Naval Academy. Mr. Tobey's work has been concerned primarily with improving practices of coal burning and the application of coal-burning equipment. He inaugurated a broad comprehensive series of fuel-engineering conferences of which 26 were ultimately held in the larger industrial centers of the United States, and attended by leading engineers of equipment manufacturers, public utilities, general industry, and fuel producers, as well as research engineers.

The purpose of these meetings was largely to co-ordinate the common interests of the coal producers, the users of coal, and the manufacturers of fuel-burning equipment. As a result of these meetings, which were attended by from 200 to 1000 people, much progress was made in improving design and operation of coal-burning plants; combustion equipment and boiler furnaces were designed with greater flexibility so that a wider range of coals could be utilized. Improved operating techniques were widely disseminated. Extensive contributions were made to engineering literature.

As an outgrowth of the curtailment of travel during the war years, technical meetings could not be held, and in order to continue his program he inaugurated the publication of Coal Reference Bulletins. These served to assist plant managers, operators, and equipment manufacturers in better application of equipment and improved operation of coal-burning plants. Much of his work during this period was directed particularly toward utilizing the more plentiful types of coal during the war period when many operations were handicapped by the severe shortages of fuel.

He has served on the Technical Advisory Board of Bituminous Coal Research, Inc., since the inception of the program and has been chairman of this board since 1940. This work has resulted in the development of smokeless space heaters and furnaces, improved stokers, better combustion on railroad locomotives, and considerable progress in the art of smoke and fly-ash elimination. Mr. Tobey has been active on the ASME Fuels Division of which he is a past-chairman.

ASME Calendar

of Coming Events

March 30–April 1
ASME, Region VIII, Annual Meeting, Baker Hotel, Dallas, Texas

April 12–14
ASME Spring Meeting, Hotel Statler, Washington, D. C.
(Final date for submitting papers was Dec. 1, 1949)

April 24–26
ASME Process Industries Division Conference, William Penn Hotel, Pittsburgh, Pa.
(Final date for submitting papers was Dec. 1, 1949)

June 12–16
ASME Oil and Gas Power Division Conference, Lord Baltimore Hotel, Baltimore, Md.
(Final date for submitting papers was Feb. 1, 1950)

June 19–23
ASME Semi-Annual Meeting, Hotel Statler, St. Louis, Mo.
(Final date for submitting papers was Feb. 1, 1950)

June 22–24
ASME Applied Mechanics Division Conference, Purdue University, Lafayette, Ind.
(Final date for submitting papers was Feb. 1, 1950)

Sept. 18–22
ASME Instruments and Regulators Division Conference, Municipal Auditorium, Buffalo, N. Y.
(Final date for submitting papers May 1, 1950)

Sept. 19–21
ASME Fall Meeting, Hotel Sheraton, Worcester, Mass.
(Final date for submitting papers—May 1, 1950)

Sept. 25–27
Petroleum Mechanical Engineering Conference, Hotel Roosevelt, New Orleans, La.
(Final date for submitting papers—May 1, 1950)

Oct. 23–25
ASME Fuels Division Conference, Hotel Statler, Cleveland, Ohio
(Final date for submitting papers—July 1, 1950)

Nov. 26–Dec. 1
ASME Annual Meeting, Hotel Statler, New York, N. Y.
(Final date for submitting papers—Aug. 1, 1950)
(For Meetings of Other Societies see page 184)

Marion Xavier Wilberding

MARION X. WILBERDING, president, Wilberding Company, Inc., Washington, D. C., was born in Louisville, Ky., Dec. 3, 1894, and educated at Purdue University. In 1913 he received a BSME. Some of the large projects within recent years which have been the responsibility of the Wilberding Company are: McLean Gardens, Naylor Gardens, and Fairlington, in all, 5000 living units for defense homes; housing developments for the National Capital Housing Authority, George Washington University Hospital, 400 beds; and Veterans Hospital, Houston, Texas, 1000 beds. Mr. Wilberding is one of the authors of "Manual of Consulting Practice for Mechanical Engineers." In the field of public utilities he has worked out economically practicable solutions for the many problems in the design, construction, and operation of public utilities and in many of the smaller communities provided facilities which are essential for prosperity and development of healthy intelligent citizens.

Fire-Technology Research Started at SRI

A Division of Fire Technology, one of the first of its kind in the nation, to work scientifically on reducing the toll of human lives and property loss from fire, was established recently at Southwest Research Institute of Houston and San Antonio, Texas.

The new division will be counseled by an advisory board composed of a number of the nation's authorities in the fire-prevention and control field.

Among its first tasks will be fundamental research programs in chemical and physical aspects of fire, combustion, and explosions in order to expand scientific knowledge of these phenomena.

The program also will include evaluation of fire-protection equipment and flame-proofing materials, the test-evaluation of fire-protection systems, as well as technological improvement in fire-extinguishing means to minimize damage to equipment designed for specific though hazardous purposes.

The services will be available to industries with fire or explosion hazards; equipment, instrument, material or extinguishant manufacturers; civic fire-fighting groups; insurance companies and inspection agencies; storage and warehousing companies, and all government agencies responsible for protection of forests, mines, industries, communities, farms, military establishments, and the general public.

ASME Sections

Coming Meetings

Arizona: February 18. Section Meeting at Phoenix. Subject: Power. Speaker to be announced.

Chicago: February 21. Railroad and Power and Fuels Divisions at Western Society of Engineers rooms. Subject and speaker to be announced.

February 27. Washington Award Dinner. Joint meeting with other societies.

Cincinnati: February 2. Engineering Societies Building.[1] Dinner at 6:30 p.m. Meeting at 8 p.m. Subject: Miami Fort Station, No. 5 Unit Addition. Speakers: H. R. Burns, E. H. Mitsch, and S. M. Hamill, Jr.

Cleveland: February 9. Cleveland Engineering Society. Dinner at 6:30 p.m. Meeting at 8 p.m. Joint meeting with Machine Design Division of Cleveland Engineering Society. Subject: Invention. Speaker: James Kirby.

Detroit: February 14. Rackham Memorial Building. Steel meeting.

Erie: February 16. Knox Hall, Church of the Covenant at 6:45 p.m. Ladies' Night—Joint dinner meeting with AIEE. Subject: Photography. Speaker: A. L. Ter Louw.

Fairfield County: February 14. Barnum Hotel, Bridgeport, Conn. Speaker: Randolph Bannow. Subject: Industrial Development in England and Sweden. Fellow certificate to be presented to E. B. Gallaher by F. M. Gunby, vice-president, ASME, Region I.

Iowa-Illinois: February 28. Ina Mae's, Muscatine, Iowa. Joint meeting with the Muscatine Engineers Club. Dinner at 6:30 p.m. followed by an inspection trip at 8 p.m. through the Soybean Processing Plant of the Muscatine Processing Corp. Speaker: G. R. Christensen.

Kansas City: February 13. University Club at 8 p.m. Subject: Gas-Turbine Power Development. Speaker: W. B. Tucker.

Metropolitan Section: February 1. Applied Mechanics-Heat Transfer Division, Room 501[1] at 7:30 p.m. Subject: Superheated Steam, 1000 F to ?. Speakers: F. S. Beach, W. S. Patterson, and P. R. Loughin.

February 7. Engineers' Forum, Room 1101[1] at 7:30 p.m. Subject: Publicity for Engineers.

February 9. Woman's Auxiliary Luncheon at Engineering Woman's Club, 2 Fifth Avenue at 12:30 p.m. Subject: Around the World on a Menu in New York, by R. W. Dana.

February 10. Junior Get-Together at Engineering Woman's Club, 2 Fifth Avenue at 6:30 p.m. Cocktails and dinner followed by talk. Subject: Opportunities for Engineers Abroad, by David Fiske.

February 14. Joint meeting, Materials Handling and Management Divisions, Room 502[1] at 7:30 p.m. Subject: Materials Handling and Other Problems of Volume Production, by A. F. Murray.

February 15. Applied Mechanics-Heat Transfer Division, Room 502[1] at 7:30 p.m. Subject: The Heat Pump, 1950, by S. J. Levine and H. A. Brysselbout.

February 20. Junior Committee, Room 501A[1] at 7:30 p.m. Subject: Trends and Opportunities in the Small Industrial Steam Plant, by S. E. Friedeberg.

February 28. Engineers' Forum, Room 502[1] at 7:30 p.m. Subject: Point Four—Good, Bad, Indifferent, by S. P. Hayes, Clifford Strike, and G. V. T. Burgess.

Pittsburgh: February 21. Location and time to be announced. Speaker: W. L. Knaus. Subject: The Design and Operation of Heat-Pump Air Conditioners.

March 21. Joint meeting with ESWP. Subject: Modern Trends in Power-Station Design. Film: Steam for Power. Speaker to be announced.

Plainfield: February 15. Elks Club, Elizabeth, N. J., at 8:15 p.m. Subject: Instrumentation. Speaker to be announced.

Youngstown: February 9. Pie and Coffee Meeting. Joint meeting with AIEE, ASM, and AWS. Subject: Iron and Steel. Motion picture by Youngstown Sheet and Tube Company.

February 23. Discussion meeting—Power. Speaker and subject to be selected by Power Subcommittee.

[1] Engineering Societies Building, New York, N. Y.

Section Activities

REPORTS of the following ASME Section Meetings were received recently at headquarters.

Central Illinois, Oct. 30. Speaker: B. G. Hatch. Subject: Present Development of Gas-Turbine Applications. Attendance: 15.

Central Indiana, Nov. 18. Speaker: J. C. Siegesmund. Subject: Engineering Problems Encountered in Pharmaceutical Industry. Attendance: 75.

Central Iowa, Dec. 14. Speaker: P. W. Trier. Subject: Producing Meat Products to Meet the Consumer's Eye and Taste Appeal. Attendance: 28.

Chicago, Nov. 15. Speaker: H. W. Browall. Subject: Carbon-Steel Product Qualities. Attendance: 55.

Dec. 20. Speaker: D. Hostedler. Subject: Instrumentation Flow-Plan Symbols. Attendance: 60.

Chicago, Junior Group, Dec. 3. Inspection trip to Southwest Sewage Treatment Works of Sanitary District of Chicago. Attendance: 85.

Cincinnati, Dec. 1. Speaker: R. G. Olt. Subject: Mechanical Engineering in Atomic-Energy Research. Attendance: 203.

Dayton, Oct. 26. Speaker: W. F. Ross. Subject: Industrial Furnaces. Attendance: 35.

Nov. 7. Joint meeting with ASTE. Speaker: Kenneth Court. Subject: Variable-Speed Hydraulic Drives. Attendance: 125.

Dec. 7. Joint meeting with AIEE. Speaker: E. W. Kettering. Subject: Diesel-Electric Locomotives. Attendance: 300.

Erie, Dec. 5. Speaker: R. F. Smock. Subject: Highways, Past, Present, Future. Attendance: 53.

Iowa-Illinois, Dec. 15. Christmas party at Plantation Club. Attendance: 34.

Ontario, Dec. 8. Speaker: P. S. Best. Subject: Industrial and Process Industries Dust Problems. Attendance: 40.

Pittsburgh, Nov. 5. Joint meeting of ASME, ESWP, and SAE. Speakers: John Brennan and R. J. Gorsky. Subjects: Hydraulic Coupling and Torque Converters. Attendance: 140.

Rochester, Nov. 10. Speaker: H. W. Stoll.

Subject: Engineering Considerations of Flow Measurement. Attendance: 57.

Dec. 8. Speaker: J. G. Hutton. Subject: Ultrasonic Materials Testing. Attendance: 57.

Rocky Mountain, Dec. 19. Speaker: C. S. Ryland. Subject: High Strength and Machinable Ceramics. Attendance: 38.

Southern Tier, Oct. 6. Speaker: P. B. Eaton. Subject: An Engineer Looks at China. Attendance: 52.

Dec. 2. Speaker: A. H. Candee. Subject: Modern Gearing. Attendance: 56.

Upper East Tennessee Subsection, Dec. 5. Speaker: F. E. Hutton. Subject: Design and Operation of Pulp-Mill Soda-Recovery Furnace. Attendance: 75.

Student Branch Activities

REPORTS of the following ASME student branch meetings were received recently at Headquarters:

University of Akron, Dec. 8. Speaker: R. Lahut. Subject: Chemical Servicing—A Must in Maintenance Programs. Attendance: 29.

Alabama Polytechnic Institute, Dec. 5. Film: Auburn Versus Clemson Football Game. Attendance: 38.

Case Institute of Technology, Dec. 6. Speaker: Captain Swanston. Attendance: 30.

Clarkson College of Technology, Dec. 14. Two films: Selecting the Right Industrial Distribution System, and The Hidden World. Attendance: 51.

Clemson College, Dec. 13. Speakers: H. K. Smith, R. S. Boston, and C. W. Farriss. Subjects: The Application of Engineering to the Tobacco Industry; Pinstock Design, Marine Boilers. Attendance: 57.

University of Colorado, Dec. 7. Speaker: L. Aspinwall. Subject: City Planning. Attendance: 45.

Colorado A and M College, Dec. 7. Business meeting and film on plastics. Attendance: 43.

Columbia University (Mechanical Division), Nov. 25. Speaker: Dr. Lucke. Subject: Application of Atomic Energy to Heat Transfer. Attendance: 65.

Cooper Union (Day), Nov. 22. Speaker: F. M. Kirt, student. Subject: Noncircular Gears. Attendance: 9.

Dec. 10. 26th annual ASME dinner. Speaker: Prof. Eastham. Attendance: 115.

Dec. 12. Speaker: J. Engelberg, student. Subject: The Analysis of Transient Vibrations by Means of a Dynamic Analog. Attendance: 12.

Cornell University, Nov. 29. Speaker: Charles Pope. Subject: Design and Lubrication Considerations in Mechanical Equipment. Attendance: 50.

Dec. 13. Speakers: Professors Conway, Loberg, Mackey, Martinuzzi, and Watson. Subject: Aspects of Engineering Education Here and Abroad. Attendance: 70.

University of Delaware, Dec. 12. Panel discussion: Where Do We Go From Here? Speakers: F. T. Bear, L. A. Darling, D. L. Hendershott, R. C. Levis, and J. J. McCarthy. Attendance: 95.

Drexel Institute of Technology, Nov. 30. Speaker: E. R. Kinnebrew. Subject: The Future of Engineering Graduates as Salesmen. Attendance: 38.

Duke University, Nov. 22. Speaker: Ira Hook. Subject: Nonferrous Metals. Attendance: 45.

Dec. 14. Film: World's Largest Plate Mill. Attendance: 24.

Fenn College, Dec. 9. Speaker: Robert Brucker. Subject: How Much Are You Worth? Attendance: 65.

University of Florida, Dec. 6. Film: An Orchid to Mr. Jordan. Attendance: 55.

George Washington University, Dec. 7. Speaker: John Clark. Subject: Engineering Aspects of Industrial Design. Attendance: 55.

University of Idaho, Dec. 5. Film: The Story of Tin Plate. Attendance: 48.

State University of Iowa, Nov. 30. Speaker: Colonel Warner. Subject: The Government Arsenal and the Engineer. Attendance: 103.

Dec. 14. Speaker: W. Olsen. Subject: What the Employer Expects of the Engineer Graduate. Attendance: 102.

Johns Hopkins University, Dec. 5. Film: Controlled Air Power. Attendance: 37.

Dec. 19. Two films on die steels and diemaking. Attendance: 45.

University of Kansas, Dec. 8. Speaker: Dr. Moore. Subject: Japan. Attendance: 175.

Kansas State College, Dec. 1. Speakers: Prof. Brainard and Prof. Tripp. Subject: Presentation of Papers at Student Branch ASME Conferences. Attendance: 250.

Dec. 15. Speaker: H. A. Davis. Subject: Hydraulic Couplings and Converters as Applied to Heavy-Duty Machinery. Attendance: 146.

University of Kentucky, Dec. 8. Presentation of "Heat-Pump Follies." Attendance: 310.

Lafayette College, Dec. 8. Speaker: J. C. Smack. Subject: Industrial Applications of Ultrasonic Testing. Attendance: 45.

Lehigh University, Dec. 8. Speaker: Mr. Sylvester. Subject: Small Companies Versus Large Companies. Attendance: 50.

Louisiana Polytechnic Institute, Dec. 7. Business meeting. Speaker: Leonard Farrell. Subject: Heat Pumps. Attendance: 40.

University of Maine, Dec. 7. Speaker: J. O. Fancuf. Subject: Plant Layouts. Attendance: 22.

Massachusetts Institute of Technology, Dec. 15. Speaker: F. A. Prahl. Subject: What to Expect of Industry and What Industry Expects of You. Attendance: 190.

University of Michigan, Nov. 15. Joint meeting with Detroit Section, preceded by dinner at the Michigan Union. Panel discussion: Whither Engineering Education? Speakers: Dean Crawford, Dean Miller, Dean Carr, and Dean Freund. Attendance: 200.

Nov. 30. Films: Quality in the Making; Styling the Motorcar; Zinc Die Casting. Attendance: 97.

Michigan College of Mining and Technology, Dec. 6. Speaker: Dr. Seeber. Subject: Problems in College and in the Engineering Field. Attendance: 42.

University of Minnesota, Nov. 22. Inspection trip to Ford plant. Attendance: 80.

Dec. 2. Quarterly party held at Columbia Chalet, Minneapolis, Minn. Attendance: 140 members and friends.

Dec. 7. General business meeting and election of officers. Attendance: 30.

University of Missouri, Nov. 30. Round-table discussion: Employment of Engineers. Discussers: Mr. Parmely, Mr. Boyles, Mr. Woodruff, and Mr. Morrell. Attendance: 85.

Dec. 14. Speaker: Forrest Nagler, vice-president, ASME Region VI. Subject: Engineering Problems. Attendance: 71.

Montana State College, Oct. 20. Speaker: R. Arboe. Subject: The Mechanical-Engineering Field. Attendance: 27.

Nov. 3. Speaker: Dr. Mullikin. Subject: The Mechanical Engineer and the Heat-Power Field. Attendance: 34.

University of Nebraska, Dec. 7. Open meeting for wives and girl friends. Program: A magic show given by Prof. Westgate. Attendance: 175.

New Mexico College of A and M Arts, Dec. 1. Speaker: R. C. Rahman, student. Subject: The Torque Converter. Attendance: 36.

College of the City of New York, Dec. 1. Speaker: F. D. Williams. Subject: Fuels and Their Applications to the Internal-Combustion Engine. Attendance: 125.

Dec. 15. Speaker: Mr. Gerber, student. Subject: Vibration. Attendance: 115.

Dec. 22. Speakers: W. M. Rogers and Mr. Proctors. Subject: Talks to illustrate color film on quality control. Attendance: 125.

Northeastern University, Nov. 29. Speakers: ASME student officers. Subject: Membership Drive. Attendance: 105.

Dec. 1. Election of officers. Attendance: 112.

Dec. 8. Film: Steam for Power. Attendance: 95.

Dec. 15. Speakers: Messrs. Stoddard and Moran. Subjects: Automatic Machinery; Industrial Electronics. Film: Applications of Automatic Machinery. Attendance: 57.

Dec. 22. Business meeting. Attendance: 56.

Northwestern University, Sept. 28. General business meeting. Attendance: 47.

Oct. 6. Get-together meeting. Attendance: 50.

Oct. 20. Films on rail steel and oil in Saudi Arabia. Attendance: 65.

Nov. 10. Films shown. Attendance: 60.

Nov. 20. Field trip to the Underwriter's Laboratory, Chicago, Ill., jointly with student members of AIEE.

Dec. 1. Speaker: R. S. Lindenmeyer. Subject: Transfer to Junior Membership. Attendance: 40.

University of Notre Dame, Dec. 6. Speaker: M. Snider. Subject: Junior Membership in ASME. Attendance: 60.

Ohio State University, Dec. 1. Speaker: J. L. Ostberg. Subject: Diesel Engines and Diesel Engineering. Attendance: 65.

University of Pennsylvania, Dec. 15. Speaker: E. B. Myrick. Subject: Development Testing of Helicopters. Attendance: 43.

Pennsylvania State College, Dec. 6. Speaker: Prof. Dusinberre. Subject: Gas Turbines. Attendance: 160.

Polytechnic Institute of Brooklyn, (Evening), Dec. 13. Speaker: Fred Seiring. Subject: What the Foundry Industry Is Today. Attendance: 51.

Pratt Institute, Nov. 21. Inspection trip to the plant of the Pratt and Whitney Company, Hartford, Conn.

Dec. 9. General business meeting. Attendance: 38.

Dec. 14. Speaker: Major Randolph. Subject: Space Travel. Attendance: 32.

Purdue University, Nov. 10. Speaker: H. H. Peterson. Subject: An Engineer in Industry. Attendance: 255.

Dec. 8. Speakers: M. L. Baas and T. L. Dahle. Subject: Personnel Placement. Attendance: 230.

Rhode Island State College, Nov. 8. Speaker: O. de Lorenzi. Subject: Firing of Pulverized Coal. Attendance: 82.

Rose Polytechnic Institute, Dec. 1. Film: Unfinished Business. Attendance: 25.

Rutgers University, Dec. 15. Speaker: H. A. Anderson. Subject: Coupling Design and Application. Attendance: 23.

University of South Carolina, Dec. 13. Film: Air Progress. Attendance: 45.

Stanford University, Nov. 30. Speaker: J. L. Crellin. Subject: Vertical Multi-Nozzle Impulse Turbine. Attendance: 29.

Syracuse University, Dec. 13. Speaker: H. W. Gracie. Subject: Engineers as Executives. Attendance: 60.

Dec. 15. Annual joint dinner meeting with senior branch of ASME. Two student papers presented by Don Miller and John Ferguson.

Dec. 20. Speaker: J. F. Carpenter. Subject: History and Development of Carrier Corporation. Attendance: 30.

University of Tennessee, Nov. 30. Election of officers. Film: U of T-Ga. Tech. Football Game, 1948. Attendance: 29.

Texas A and M College, Nov. 15. Speakers: Messrs. Latimer and Fields. Subject: Technical Writing. Attendance: 59.

Dec. 6. Speakers: J. E. Richards and J. C. Flanagan. Subject: Competitive Speeches by ME Students. Attendance: 53.

University of Texas, Oct. 3. Speakers: Prof. Eckhardt, B. Short, and Prof. Doughtie. Subject: ASME, History, Purpose, Achievement, and Benefits. Attendance: 268.

Dec. 12. Speaker: M. W. Williams. Subject: Modern Foundry Operation. Attendance: 44.

University of Vermont, Nov. 17. Speaker: Mr. Lybeck. Subject: Saudi Arabia. Attendance: 54.

University of Virginia, Dec. 16. Speaker: Dr. Lyon. Subject: Heat Transfer in Liquid Metals. Attendance: 45.

Virginia Polytechnic Institute, Nov. 29. Film: Harnessing Liquids. Attendance: 100.

State College of Washington, Dec. 1. Film: Mechanical Refrigeration. Attendance: 48.

Dec. 15. Speaker: Dr. Albrook. Subject: Work in Mechanical Engineering. Attendance: 29.

University of Washington, Nov. 30. Speaker: R. W. Fredericks. Subject: Types of Spark Plugs Used in Ignition Systems. Attendance: 80.

Wayne University, Dec. 7. Speaker: Prof. Perkins. Subject: New Wayne University Engineering Building. Attendance: 62.

University of Wisconsin, Dec. 7. Film: A Hidden World. Attendance: 95.

Yale University, Dec. 13. Speaker: V. J. Scully. Subject: Development of Modern Architecture. Attendance: 25.

Candidates for Membership and Transfer in the ASME

THE application of each of the candidates listed below is to be voted on after Feb. 25, 1950, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

R = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

ALCORN, DONALD G., Hartsdale, N. Y.
ALLINSON, REGINALD J., Vancouver, B. C., Can.
ANDERSON, ANDREW, S. Orange, N. J.
ANDERSON, H. M., Houston, Texas
BALHOUSE, HAROLD J., Schenectady, N. Y.
BARTLETT, ROLAND W., Wilmington, Del.
BAZZONI, JOSEPH P., Chicago, Ill.
BECK, HILDING V., Erie, Pa. (Rt & T)
BECKER, HERBERT P., New York, N. Y.
BECKER, WILLIAM O., Ozone Park, N. Y. (Rt & T)
BENNETT, DONALD, W., Hyattsville, Md.
BOCHENSKI, ERNEST F., Brooklyn, N. Y.
BOISSEVAIN, M. G. J., Brooklyn, N. Y.
BROWN, F. H. S., Liverpool, England
BULLOCK, A. F., Birmingham, Ala.
CALISE, VINCENT J., Long Beach, N. Y.
CARLSON, PAUL E., Cresskill, N. J. (Rt & T)
CASEY, THOMAS J., Rockville Center, N. Y.
CHRISTMAN, JACK M., Newark, Del.
CLEVER, WILLIAM R., Port Allegany, Pa.
COGBURN, C. O., Fayetteville, Ark.
COLE, E. SHAW, New York, N. Y.
COLLING, ROBERT E., Mt. Vernon, N. Y.
CROCKER, BERNARD, JR., Raleigh, N. C.
DELLACANONICA, O. G., Schenectady, N. Y.
DESROCHERS, FERNAND, Toronto, Ont., Can.
DONOVAN, JOHN F., JR., Kansas City, Mo.
EDEL, LEONARD J., Boston, Mass.
ELLIS, F. J., Thorold, Ont., Can. (Rt & T)
FIPE, CHARLES E., Los Angeles, Calif.
FORMAN, GEORGE W., Kansas City, Mo.
FRANKLIN, B. J., Port Elizabeth, South Africa
FRISA, HENRY H., Jeannette, Pa.
GAY, HOXIE C., JR., Cabin Creek, W. Va.
GEIST, WALTER, Shorewood, Wis. (Rt)
GOODSON, G. ROYDEN, JR., Lynchburg, Va.
GOYNE, RICHARD J., Conshohocken, Pa.
HALL, ARTHUR G., Wauwatosa, Wis.
HANOT, WILLIAM, Seattle, Wash.
HAYMES, ELDRIDGE, New York, N. Y.
HEPOLA, GEORGE E., Clintonville, Wis.
HIGGINS, MAX B., New York, N. Y.
JEPPESEN, LYLE ROBERT, Mound, Minn.
KERSEY, EVERETT E., Orange, Texas
KING, G. W. K., Detroit, Mich.
LEMBESIS, CHRISTY, Long Beach, Calif.
LEMLEY, C. BURL, Port Arthur, Texas
LESNIAK, FRANK G., Laurel, Miss. (Rt & T)
MCKEOWN, R. J., Montreal, Que., Can.
MICHEL, PHILIP L., Raleigh, N. C.
MONNELL, RALPH D., JR., Jenkintown, Pa.
MURRAY, LEO P., Ross, Calif.
NIEBLING, LOUIS H., St. Louis, Mo. (Rt & T)
OLDENBURGER, RUFUS, Chicago, Ill.
PECK, THEODORE H., Rochester, N. Y.
PFAHLER, R. D., Washington, D. C. (Rt & T)
PLESSET, MILTON S., Pasadena, Calif.
POWERS, ROBERT F., Schenectady, N. Y.
RAINS, CLORAL O., Bartlesville, Okla.
RIPPERGER, E. A., Austin, Texas
ROBY, RAYMOND L., Mitchell, S. D.
ROLLERT, EDWARD D., W. Hartford, Conn.
SCHIEFER, RICHARD B., Buffalo, N. Y.
SMITH, RAYMOND W., Kingsport, Tenn.
SNOWDEN, EARL W., Kirkwood, Mo.
SOSSIN, SYDNEY, Philadelphia, Pa.
STANISIC, MILOMIR M., Chicago, Ill.
STOTT, T. E., JR., Medway, Mass.
SWANN, WM. H., Opportunity, Wash.
THEODORIDES, PHRIXOS J., Cambridge, Mass.
THOMAS, ARTHUR, Temple City, Calif.
VAGTBORG, H. A., San Antonio, Texas
VERNER, ALAN E., Baltimore, Md.
WHEELER, WILMOT F., JR., Mt. Kisco, N. Y.
WISE, H. H., Jeffersonville, Ind.
WITTKE, W. J., Springfield, Ohio
WRIGHT, JOHN N., Pittsburgh, Pa.
ZOLLI, BASIL V., Los Angeles, Calif.

CHANGE IN GRADING

Transfers to Member and Associate

ALVES, GEORGE E., Newark, Del.
ASTLEY, WAYNE C., Villanova, Calif.
CHAPMAN, REGINALD E., Toronto, Ont., Can.
DANSIE, G. W., JR., Salt Lake City, Utah
FERGUSON, DONALD MCHARDY, Beverly, Mass.
FUGLER, RONALD W., Shawinigan Falls, Que., Can.
GRANBERRY, E. HERMAN, Shawmut, Ala.
GREEN, LEWIS E., Wesleyville, Pa.
HATCH, ALBERT M., Stoneham, Mass.
HELDACK, JOHN M., Phoenix, Ariz.
HUNTER, ARTHUR T., Montgomery County, Pa.
KERN, ROBERT D., Downey, Calif.
KING, R. M., Memphis, Tenn.
KOCH, WILLIAM A., Detroit, Mich.
KOCHLACS, ALEXANDER J., Alhambra, Calif.
KOENIG, WILLIAM C., Hastings, Neb.
KORSTIAN, ROBERT J., Durham, N. C.
LAFFERTY, EDWARD C., Springfield, Ohio
MAGUIRE, JAMES, Mason, Mich.
MAHER, ROBERT LEE, Waterbury, Conn.
O'ROURKE, J. T., New York, N. Y.
RADOW, HIMAN, Richland, Wash.
SCHMIDT, FRED J., Fort Wayne, Ind.
SINGH, JAGIR, Calcutta, India
SKENE, E. MATTHEW, Hempstead, N. Y.
STEPHENSON, WILLIAM K., Chicago, Ill.
VOGT, PAUL R., Los Angeles, Calif.
WATT, JOHN R., Austin, Texas

Transfers from Student Member to Junior 75

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., in co-operation with the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to all engineers, members or not, and is operated on a nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrant members whose availability notices appear in these columns. Apply by letter, addressed to the key number indicated, and mail to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available at a subscription of $3.50 per quarter or $12 per annum for members, $4.50 per quarter for nonmembers, payable in advance.

New York 8 West 40th St. | **Chicago** 84 East Randolph Street | **Detroit** 100 Farnsworth Ave. | **San Francisco** 57 Post Street

MEN AVAILABLE[1]

PROJECT ENGINEER, BSME, 1937, experienced in heavy machinery, industrial engineering, presently employed in petroleum-industry stress analysis, equipment redesign, and inspection. Desires work directing equipment redesign and testing. Midwest or Southwest preferably, but not essential. Me-603.

MECHANICAL-INDUSTRIAL GRADUATE, presently employed, three years' experience in piping design and layout, desires chance to become associated with company to build future, where possibility exists of eventually being advanced to the industrial-engineering phase of operations. New York, Massachusetts, or East, but not essential. Me-604.

ENGINEERING EXECUTIVE, 39, married, BS Mechanical (Management) Engineering, W. Va., 1933. Professional License, W. Va. Six years plant construction, eight years production, two years sales. Me-605.

EXECUTIVE ENGINEER, chemical and mechanical. Twenty years' diversified experience. Supervision of plant and process development, design, construction, and operation. Equipment design and applications. Sales and consulting. Project management. Me-606.

MECHANICAL ENGINEER, fifteen years' experience in machine design, product engineering and development, tool design, engineering, and manufacturing supervision. Desires permanent connection with well-established and progressive company. Me-607.

MECHANICAL ENGINEER, 41, graduate Purdue. Ten years' experience with manufacturer of small precision instruments, in charge of process planning, special tooling, and development of new products. Northwestern Pennsylvania preferred. Me-608.

MECHANICAL ENGINEER, 30, BME, one and a half years' experience on design of railroad cars, two years mapping, U. S. Army Engineers, two years drafting, steam autoclaves, and allied. Certificate of engineer in training, New York State. Foreign languages. Own car. Location, immaterial. Me-609.

MECHANICAL ENGINEER, 26, married, MIT, Cornell, BME, PE, three years' varied analytical and design experience for manufacturer of heavy equipment. Desires responsible assistantship to competent engineer in manufacturing plant. East Coast preferred. Me-610.

DIE-DESIGN ENGINEER, 40, Cooper Union. Wide experience in the plastic workings of metals. Past twenty years with manufacturer of punch presses, canmaking machinery, and dies. In charge of a group of die designers. Desires supervisory position connected with the metal-stamping industry. New York or New Jersey. Me-611.

MECHANICAL ENGINEER, qualified to handle everything from statistical quality control to electrical and structural design and improvement of boiler economy. Interested in connecting with a small plant. Me-612.

PROFESSIONAL ENGINEER, 38, well known in fields of heat transfer, rheology, and applied mechanics, desires position in industry. Me-613.

RECENT GRADUATE, 25, married, BME, honors, Sigma Tau, Phi Kappa Phi, University of Florida. Desires position with future in any phase of mechanical engineering. Prefers air conditioning, research, and development. Me-614.

ENGINEERING-BUSINESS, Mechanical Engineer, 25, BA, Duke 1947 in Business, BSME, University of Va., Feb. 1950. Experience: electronics, machinist, electric power, air conditioning, refrigeration, sales, design, estimating. Desires position with management in an engineering business. Location open. Me-615.

MANUFACTURING EXECUTIVE, 41, registered professional engineer. Aggressive, resourceful, and energetic with broad, successful, industrial experience in directing and co-ordinating all phases of manufacturing, planning, engineering, purchasing, production, sales, accounting, and industrial relations. Me-616.

MECHANICAL ENGINEER, MME, PE, 34, diversified design-development experience hydraulic drive, power servos, paper, special machinery, plant layout, installation, maintenance, project or supervisory position. New York, N. Y. preferred. Will travel occasionally. Me-617.

INDUSTRIAL ENGINEER, 25, single, BSIE, Lehigh, disabled veteran. Experience in metal and plastic inspection and testing. Methods, time-study, or sales-service position desired. Will relocate or travel. East preferred. Me-618.

MECHANICAL ENGINEER, 25, graduate, single, BSME. Willing to work and learn. Locate anywhere. Me-619.

TECHNICAL SALES EXECUTIVE, capable building or reorganizing force of sales engineers and formulating plans and policies for technical or semitechnical line. Married, age 37. Prefers New England. Me-620.

MECHANICAL ENGINEER, young, capable. MIT graduate. Navy electronics experience. Formerly with aircraft jet program. Seeks permanent position with industrial or consulting firm. Machine design, development, assistant to mechanical engineer. Me-621.

MECHANICAL ENGINEER, 23, BSME, University of California, single, recent graduate, seeks position in production, design, or research. Presently located in East. Location immaterial. Me-622.

MECHANICAL ENGINEER, graduate, 22, design and drafting experience in the graphic-arts field; some machine-shop experience. Desires machine-design or heat and power fields, will relocate; present residence Brooklyn. Me-623.

ENGINEER, 34, Registered Professional Engineer, production and plant engineering, design chemical-process equipment, tablet presses, welded-steel-plate construction, ceramic equipment. Desires position as assistant chief engineer, chief draftsman, or salesman. Philadelphia area. Me-624.

ENGINEER, young, presently employed, having almost two years' industrial experience in product design and cost reduction. Wishes to assist progressive firm to lower today's high production costs. Me-625.

MECHANICAL ENGINEER, graduate, 36, thirteen years' general engineering experience in plant maintenance and construction. Desires permanent position as chief engineer or plant manager. Me-626.

MECHANICAL ENGINEER, 26, married, three years machine design and development, two years jig and fixture design, one year production control, inspection, service, and general engineering. Fluent French. Capable assuming responsibilities. Me-627.

INDUSTRIAL ENGINEER, 43, married, mechanical graduate, registered professional engineer, Washington State. Sixteen years' experience in the fields of industrial engineering and wage administration. Those years in highly responsible supervisory positions. Thirty days' notice necessary. Prefers Pacific Coast. Me-628-4912-D-15.

[1] All men listed hold some form of ASME membership.

POSITIONS AVAILABLE

MECHANICAL ENGINEER with some electrical background, who has had some plant-maintenance experience, to make inspections on large projects, make recommendations for corrective measures, cutting costs; should be able to prepare estimates of costs and check budgets for

(*ASME News continued on page 198*)

A COMPLETE SYSTEM...

FOR INSTANT, ACCURATE CHECK ON LIQUID OR BOILER WATER LEVELS THROUGHOUT THE PLANT

Yarway Remote Liquid Level Indicator with Control Unit attached.

Now you can have constant check-up on water levels wherever —and whenever—you want.

The Yarway Liquid Level Indicator, equipped with Yarway Control Unit and auxiliary electric signalling devices, provides this check at two or more locations anywhere in the plant.

The Yarway Indicator is always accurate because it is operated by the liquid itself. Indicating mechanism is never under pressure. There are no stuffing boxes. Complete separation of indicating and actuating parts is achieved by permanent magnet transmission.

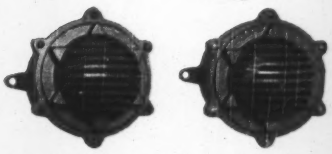
The Automatic Control Unit is attached directly to the Indicator and operates the remote signal alarms (light or horn) at any remote locations.

The Control Unit may also be used as a control for mechanical equipment such as motor-operated valves, pumps, etc.

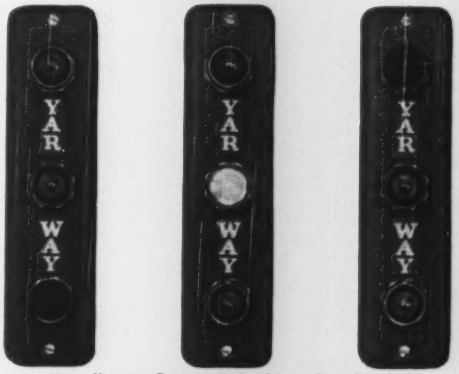
FOR COMPLETE DESCRIPTION AND SPECIFICATIONS OF YARWAY REMOTE LIQUID LEVEL INDICATORS, WRITE FOR BULLETIN WG-1822.

YARNALL-WARING COMPANY
108 Mermaid Ave., Philadelphia 18, Pa.

NEW!
A RECORDING BOILER WATER LEVEL INDICATOR—THE YARWAY HI-LO-GRAPH. SEE BULLETIN WG-1830.



Yarway Remote Hi-Lo-Alarm Signal Horns.



Three Yarway Remote Hi-Lo-Alarm Signal Lights, showing low level, normal operation and high level. Each unit shows all levels.

YARWAY REMOTE LIQUID LEVEL INDICATOR

mechanical work. Should have had extensive practical as well as theoretical experience on heating systems, coal- and oil-fired; utility lines, water, gas, and electric, also plumbing. Should have had some construction experience on large projects. Some traveling in New York, New Jersey, and Pennsylvania. $6400. Headquarters, New York, N. Y. Y-3092.

DESIGNER to head up mechanical section. Should have about ten years' experience in the actual design of heating, plumbing, and air-conditioning systems for hospitals, apartment buildings, laboratories, office buildings, and industrial plants. Must be willing and capable of drawing up own designs when necessary to meet rush schedules. $5400–$6600. Georgia. Y-3101.

DESIGNER, 30–35, mechanical graduate, with eight to ten years' experience on medium-heavy equipment for design and development of processing equipment in glass industry. $4000–$5000. South. Y-3134.

DESIGNER, 35–45, mechanical graduate, with at least five years' plumbing, heating, and air-conditioning design experience in mechanical trades of construction industry, to design and lay out facilities for hospitals, schools, and commercial buildings. $5000–$6000. Illinois. Y-3137-C.

CHIEF DESIGN Engineer, 35–45, with at least five to ten years' experience in electromechanical design on small light mechanisms. Must be a good administrator and know how to make low-cost designs. $6000–$7000. Connecticut. Y-3138.

DEVELOPMENT AND DESIGN ENGINEER, 28–38, graduate, with BS degree in mechanical or electrical engineering, with minimum of eight years' experience in engineering or allied fields, of which a minimum of five years' experience as project engineer in charge of design on photographic equipment, instruments, small precision mechanical devices, etc. Experience in tool design, machine shop, cost estimating, or production engineering desirable. Salary, dependent on qualifications. Upstate New York. Y-3145.

MECHANICAL ENGINEER, to take charge of manufacturing and engineering, with at least five to ten years' experience in air-compressor, steam-engine, or Diesel-engine design, and construction. Salary open. Pennsylvania. Y-3147.

STAFF ASSISTANT TO CHIEF INDUSTRIAL ENGINEER, 30–35, graduate. Under general supervision of chief industrial engineer, will promote efficient materials-handling and warehousing techniques by directing or leading others and/or by personally carrying out industrial-engineering surveys and investigations on assigned projects. $6000. New York, N. Y. Y-3156.

INDUSTRIAL ENGINEER, 35–40, with broad experience in materials handling and warehousing, for work in the large department-store field; experience therein helpful. Management consulting experience in the materials-handling and warehousing field helpful. Should be capable of contacts and association with top managements in a large corporation. $7500 and up depending on experience. New York, N. Y. Y-3161.

ASSISTANT SALES MANAGER, 25–40, mechanical background, with experience with national distribution and merchandising; able to handle field problems, manage department, interpret company policies, deal with an organization comprising forty to fifty district offices and around thirty branch sales offices, plus an extensive national dealer-distributor setup. Will spend much time in main sales office attending to manager's administrative duties for a manufacturer of electrical and pneumatic tools and other mechanical equipment. About $7000. Illinois. R-6120.

DEVELOPMENT AND DESIGN ENGINEER, up to 45, mechanical engineer or equivalent, with minimum of eight to ten years' experience with flat steel strapping equipment. Knowledge of devices and shop equipment, tooling, and manufacturing desirable, able to direct development and provide analytical reasoning to other departments. Deal with design problems on board at outset for a manufacturer. $5000 and up. Illinois. R-6123.

SALES ENGINEER, mechanical, able to draft preliminary plans, secure field information (dimensions, applications, and installation) and to make estimates for consulting engineers, constructors, factory engineers, or industrial companies interested in coal-handling, conveyer, and elevator equipment for a manufacturer. $4500–$5000. Some traveling. Illinois. R-6148.

ASSISTANT CHIEF ENGINEER, mechanical background, well-qualified, administrative, and operational engineer, qualified technically and able to carry administrative responsibility and direct a department comprising fifty engineers for manufacturing a device of complicated nature in a highly competitive field, essentially lightweight equipment, thoroughly informed regarding punch presses, drill presses, and screw machines, intricate tooling, and other high-speed production and application of other high-speed production equipment for a manufacturer. $10,000–$12,000. West Coast. R-6149.

Obituaries

Asa White Kenney Billings (1876–1949)

ASA W. K. BILLINGS, former president, Brazilian Traction, Light, and Power Co., Ltd., Rio de Janeiro, Brazil, and construction engineer for hydroelectric developments in Spain, Mexico, and South America, died in La Jolla, Calif., Nov. 3, 1949. Born, Omaha, Neb., Feb. 8, 1876. Parents, Albert S. and Abbie A. (Park) Billings. Education, AB, 1895; AM, 1896, Harvard University. Married Josephine Jordana y Bada. Honorary degree of EE, Tufts, 1929; U. S. Distinguished Service Cross; French Legion of Honor, Commander of the Southern Cross (Brazil). Mem. ASME, 1909. Mem. ASCE, AIEE, Institute of Civil Engineers of London (England). Commander, U. S. Navy, 1917–1918. Survived by wife, son, A. W. K. Billings, Jr., Wellesley Hills, Mass., and daughter, Mrs. Mary B. Warner, Winnetka, Ill.

Carter Stanard Cole (1896–1949)

CARTER S. COLE, assistant technical secretary, American Society for Testing Materials, died in Philadelphia, Pa., Nov. 17, 1949. Born, Culpeper, Va., Oct. 29, 1896. Parents, J. Thompson and Annie (Lee) Cole. Education, BA, University of Virginia, 1917. Married Dorothy W. Stevens, 1926. Assoc. Mem. ASME, 1930, Mem. ASME, 1935. Mem. SAE, AIME, ASTM, Institute of Metals of London (England). Survived by wife and two children, Anna Stevens, and Carter Lee; and a sister, Anne Lee Cole.

Lloyd Albert Corwin (1887–1949?)

LLOYD A. CORWIN, whose death was reported to the Society, was general superintendent and chief engineer, Froedtert Grain and Malting Co., Inc., Milwaukee, Wis. Born, Appleton, Wis., June 17, 1887. Parents, Albert and Minnie Corwin. Education, six years Extension Division, University of Wisconsin. Married Elsie B. Miller, 1914. Mem. ASME, 1939. He had articles published in *Power* on fuels and power-plant operation. Survived by wife and two children, Ruth H. and Jean H.

Cornelius W. DeForest (1878–1949)

CORNELIUS W. DEFOREST, widely-known authority in the electrical-utility field and consultant to the Economic Co-Operation Administration of the U. S. Government, died in Washington, D. C., Nov. 17, 1949. Born, Brooklyn, N. Y., Sept. 19, 1878. Parents, David William and Sophie Chase (Morrow) DeForest. Education, evening classes, Columbia University. Married Julia Morrow, 1928. Mem. ASME, 1922. Survived by wife.

Hobart Cutler Dickinson (1875–1949)

HOBART C. DICKINSON, inventor, physicist, and former chief of Heat and Power Division, National Bureau of Standards, Washington, D. C., died Nov. 27, 1949. Born, Bangor, Maine, Oct. 11, 1875. Parents, George Lyman and Emma (Cutler) Dickinson. Education, BA, 1900; MA, 1901, Williams College; PhD, Clark University, 1910. Married Elizabeth Wells, 1903, (died, 1921); children, David (deceased), Bradley Wells (adopted). Married 2nd, Mabel V. Kitson, 1923, one daughter, Anna Katherine. Mem. ASME, 1919, Fellow ASME, 1949. Fellow AAAS, Mem. American Physical Society, ASTM, American Society of Refrigerating Engineers, SAE (president, 1923), Washington Academy of Sciences, Washington Philosophical Society, District of Columbia Traffic Advisory Board. Author and joint author of numerous bulletins, Bureau of Standards; papers published by ASTM, SAE, ASRE, and NACA. Author of "The Mechanics of Prosperity." He spoke and wrote much about automobiles and traffic problems. In 1930 he was one of the ten delegates chosen to represent the United States at the World Power Conference in Berlin, Germany. Survived by wife, a son, and a daughter.

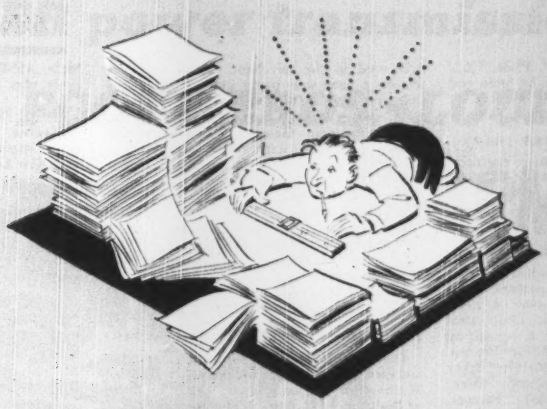
Bernard Martin Fine (1890–1949)

BERNARD MARTIN FINE, consulting engineer, Midvale Co., Philadelphia, Pa., died at Temple University Hospital, Philadelphia, Oct. 27, 1949. Born, Philadelphia, March 19, 1890. Parents, Samuel and Dora (Sobel) Fine. Education, Drexel Institute of Technology, Temple University. Married Amelia Shankroff, 1916. Held numerous patents in various fields. Jun. ASME, 1914; Mem. ASME, 1935. Survived by wife.

Stanley Thomas Goss (1884–1949)

STANLEY T. GOSS, president, Goss and DeLeeuw Machine Co., New Britain, Conn., died Oct. 31, 1949. Born, Winnetka, Ill., March 11, 1884. Parents, Charles Oliver and Ida E. (Stanley) Goss. Education, Chicago Manual Training School; ME department, University

(*ASME News continued on page 200*)



Having SLIDE RULE trouble?

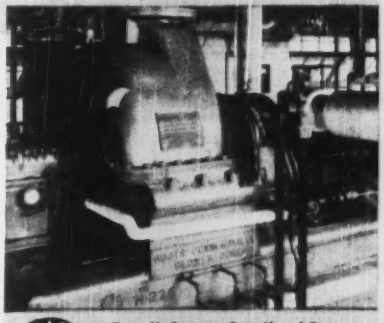
When the problem is moving air or gas, turn to *R-C dual-ability* to supply accurate, dependable answers

That's one job we know, inside-out. For almost a century, we've been air-and-gas specialists, exclusively. Without being immodest, we think our engineers are the best informed in the industry, on blowers, exhausters, gas pumps and related equipment.

They have an extensive line to draw on, too. They make unbiased recommendations between Centrifugals and Rotary Positives—we're the only company offering this *dual choice*. With capacities ranging from 5 cfm to 100,000 cfm, we can supply standard units closely matched to the job, for efficiency and economy.

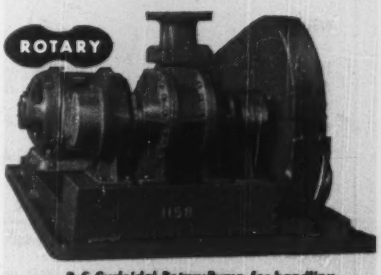
As to how R-C equipment performs, our old-time, repeat customers are the best answer to that. They'll testify that you will reduce your buying and operating problems when you call on R-C air-and-gas specialists.

ROOTS-CONNERSVILLE BLOWER CORPORATION
502 Michigan Avenue, Connersville, Indiana



CENTRIFUGAL

Type H, 2-stage Centrifugal Exhauster for coke oven plant. Capacity 16,850 cfm.



R-C Cycloidal Rotary Pump for handling gas or vapor, together with liquids, in petroleum or chemical processing.

ROOTS-CONNERSVILLE
BLOWER BUILDERS SINCE 1854
ONE OF THE DRESSER INDUSTRIES

DOING ONE THING WELL FOR ALMOST A CENTURY

of Illinois. Married Louise F. Platt, 1912. Mem. ASME, 1914. Survived by wife and three children, Charles P., Mrs. George W. Young, Helen P., all of New Britain, Conn.

William Charles Groff (1888–1949)

WILLIAM C. GROFF, consulting engineer, Richmond Heights, Mo., died May 31, 1949. Born, St. Louis, Mo., Feb. 8, 1888. Education, Christian Brothers College. Mem. ASME, 1940.

Francis Hodgkinson (1867–1949)

FRANCIS HODGKINSON, mechanical engineer and inventor who held 101 patents, principally on steam turbines, died Nov. 4, 1949, in St. Vincent's Hospital, Toledo, Ohio, after a long illness. He was retired as consulting mechanical engineer, Westinghouse Electric and Manufacturing Co. in 1936, after forty years of service for that company. Born, London, England, June 16, 1867. Parents, Francis Otter and Margaret (Thompson) Hodgkinson. Education, Royal Naval School, New Cross, England; Armstrong College, Newcastle, England. Married Edith M. K. Piercy, 1897. Honorary professor, mechanical engineering, Columbia University. Awarded Louisiana Purchase Exposition Silver Medal, 1904; Elliott Cresson Gold Medal, The Franklin Institute, 1925; Willians' Gold Medal, The Institution of Mechanical Engineering and Institution of Electrical Engineering of Great Britain, 1931; honorary degree of mechanical engineering, Stevens Institute of Technology, 1935; Holley Medal, ASME, 1938. Mem. ASME, 1902, Fellow ASME, 1939; Hon. Mem. ASME, 1947. Served as vice-president, ASME, 1939–1941; chairman, Committee on Power Test Codes, 1937. Mem. AIEE, Engineering Society of Western Pennsylvania, The Institution of Mechanical Engineers. Survived by three sons, Francis Piercy, Toledo, Ohio; George Arthur, Short Hills, N. J.; William Sampson, West Newton, Mass.; and five grandchildren.

Charles Volney Kerr (1861–1949)

CHARLES V. KERR, mechanical engineer credited with developing the first steam turbine used in the merchant marine and perfecting a deep-well pump used in the citrus industry, died in Los Angeles, Calif., Oct. 30, 1949. Born, Miami County, Ohio, March 27, 1861. Parents, George Washington and Nancy (Collins) Kerr. Education, PhB, Western University of Pennsylvania (now University of Pittsburgh) 1884; PhM, 1888; honorary PhD, 1898; ME, Stevens Institute of Technology, 1888. Married Libbie Applebee, 1888; children, Clifton A. (deceased), Vida A. (deceased), Delia A., Volney A., Marion A. (deceased). Mem. ASME, 1892. Survived by wife, a daughter, Mrs. Martin Duke, Glendale, Calif., and a son, Volney A., Colton, Calif.; two grandsons.

Daniel Everett McDonald (1907–1949)

DANIEL E. MCDONALD, superintendent, tools and dies, R. W. Wallace and Sons, silversmiths, Wallingford, Conn., died Oct. 5, 1949, at Wallingford. Born, Idaho Springs, Colo., Dec. 31, 1907. Education, extension courses at Rutgers University, Pennsylvania State College, and University of Wisconsin. Jun. ASME, 1943; Mem. ASME, 1947. Survived by a daughter, Marilyn; his wife died some time ago.

James Hood Miller (1897–1949)

JAMES HOOD MILLER, president, James Hood Miller, Inc., Pittsburgh, Pa., died in Pittsburgh, Aug. 4, 1949. Born, Wilkinsburg, Pa., June 30, 1897. Parents, James Milton and Margaret M. (Hood) Miller. Education, BA, Washington and Jefferson College, 1919. Married Elinor Durrington Stephenson, 1923. Assoc. ASME, 1946. Survived by wife.

Rudolf Pollak (1887–1949)

RUDOLF POLLAK, chief engineer, Rockefeller Center, New York, N. Y., from 1945 until his death also held the post of chief of the center's department of consulting engineering and design. He died Nov. 6, 1949, at Roosevelt Hospital. Born, Brooklyn, N. Y., May 21, 1887. Parents, Jacques and Mary Pollak. Education, ME, Stevens Institute of Technology, 1908. Married Mary Jane Shimp. Mem. ASME, 1937. Survived by wife and a sister, Mrs. Graham Harris.

Walter Samuel Rearick (1897–1949)

WALTER S. REARICK, vice-president and works manager, Aluminum Cooking Utensil Co., New Kensington, Pa., died at his home in Pittsburgh, Pa., Nov. 12, 1949. Born, Center Hall, Pa., Jan. 30, 1897. Parents, James P. and Margaret (Walters) Rearick. Education, BSME, Pennsylvania State College, 1924. Married Elsie Ament. Mem. ASME, 1941. Survived by wife, two brothers, and three sisters.

Fred Wayland Rose (1877–1949)

FRED W. ROSE, consulting engineer, St. Paul, Minn., died March 14, 1949. Born, Mazon, Ill., June 24, 1877. Parents, David A. and Emma M. Rose. Education, BS, University of Illinois, 1903. Married Blanche S. Runyon, 1913; children, Elizabeth, Wayland, Warren, Roger. Assoc. ASME, 1913; Mem. ASME, 1917.

John Medric Rugh (1882–1949)

JOHN M. RUGH, mechanical engineer, Geneva Mills, Wanskuck Co., Providence, R. I., died Nov. 7, 1949. Born, Biddeford, Maine, March 24, 1882. Parents, Adolphus and Leontine Rugh. Education, public schools in Maine. Married Flora Gledhill, 1906; daughter, Mary V. Mem. ASME, 1933.

Harry Everett Stoeltzing (1879–1949)

HARRY EVERETT STOELTZING, recently retired as division engineer, Board of Transportation, New York, N. Y., died Nov. 16, 1949, in the home of his daughter, Mrs. Calvin F. Kay, in Bryn Mawr, Pa., after a long illness. Born, Pleasantville, Pa., March 17, 1879. Education, Pennsylvania State College. Mem. ASME, 1916.

Lucius Erskine Whiton (1862–1949)

LUCIUS E. WHITON, industrialist, inventor, banker, chairman of D. E. Whiton Machine Co., and civic leader, died at the Lawrence Memorial Hospital, New London, Conn., Nov. 10, 1949. Born, West Stafford, Conn., Dec. 25, 1862. Parents, David Erskine and Asenath (Francis) Whiton. Education, graduate, Wilbraham (Mass.) Academy, 1881. Married Viola E. King, 1887 (deceased). Member ASME, 1905. State representative, 1907, 1909, and 1911 sessions of the general assembly of Connecticut. State senator in the 1915 session; chairman of the legislature's committee on railroads. Survived by three daughters and a sister.

ASME Master-File Information

Please Print — **Check Mailing Address**

Name ..... (Last, First, Middle)

Home Address ..... ☐ (Street, City, Zone, State)

Name of Employer .....

Address of Employer ..... ☐ (Street, City, Zone, State)

Product or Service .....

Title of Position Held .....

Nature of Work Done .....

I am a subscriber of (please check)

Transactions.. ☐ Journal of Applied Mechanics.. ☐ Applied Mechanics Review.. ☐

Notify Headquarters Promptly of Changes

Keep Your ASME Records Up to Date

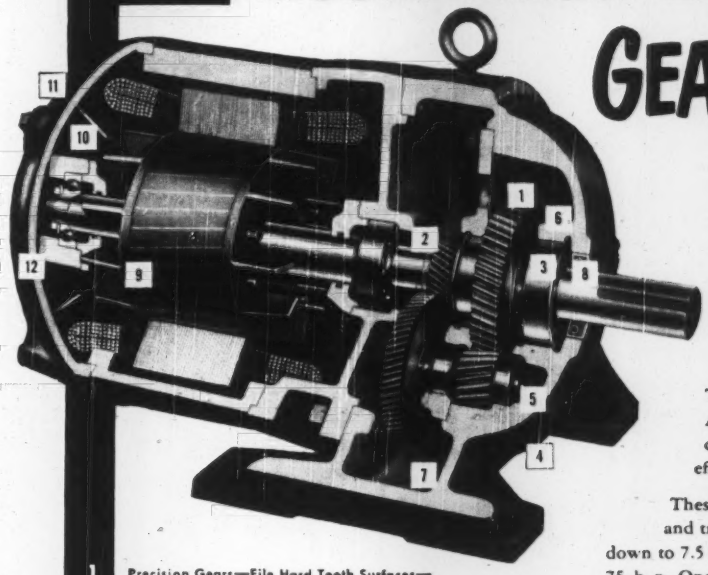
HEADQUARTERS depends on its master membership file for answers to hundreds of inquiries daily pertaining to its members. All other Society records and files are kept up to date through changes processed through it. The listings in future ASME Membership Lists will be taken directly from the master file. It is important to you that it lists your latest mailing address and your current business connection.

The mailing form on this page is published for your convenience. You are urged to use it in reporting recent changes.

Your mailing address is important to Headquarters. Please check whether you want your mail sent to home or office address.

for BETTER power transmission

FOOTE BROS.-LOUIS ALLIS GEARMOTORS



1 h.p. double reduction unit with output speeds from 230 R.P.M. to 45 R.P.M.

The new line of Foote Bros.-Louis Allis Gearmotors offers industry new compactness in design — improved efficiency in operation — longer life.

These units are available in single, double and triple reductions, output speeds of 780 down to 7.5 R. P. M., in ratings of 1 h. p. through 75 h. p. Open drip-proof, splash-proof, enclosed and explosion-proof motors are available.

These drives are compact in design with sturdy cast housings, streamlined inside and out. Precision helical gears have file-hard tooth surfaces and tough, resilient cores, giving long-wear life and maximum load carrying capacity. Mail the coupon for bulletin.

FOOTE BROS. GEAR AND MACHINE CORPORATION
Dept. Q, 4545 South Western Boulevard • Chicago 9, Illinois

1	Precision Gears—File Hard Tooth Surfaces—Resilient Cores
2	Tang Driven Motor Shaft Pinion provides positive locking without small keyways
3	Extra Capacity Ball or Tapered Roller Bearings
4	Cast Iron Construction for maximum rigidity under load
5	Corner Mounted Offset Shaft—More Compact Design
6	Unit Case with Integral Bearing Housings Maintains Gear Alignment
7	Large Oil Reservoir—Efficient Splash Lubrication
8	Leakproof Oil Seals
9	Dynamically Balanced, Die Cast Aluminum Rotor
10	Impregnated Windings Protect from Moisture, Weak Acids, Alkali, Dust and Oil
11	Cast Iron Housing, Head and Flange Insure Strength and Rigidity
12	Ball Bearing Motor for Trouble-free Operation

Single Reduction *Double Reduction* *Triple Reduction*

FOOTE BROS.

Better Power Transmission Through Better Gears

Foote Bros. Gear and Machine Corporation
4545 S. Western Blvd., Chicago 9, Illinois

Gentlemen: Please send me a copy of Bulletin AGM with Information on Foote Bros.-Louis Allis Gearmotor.

Name.....

Company.....

Address.....

City.....*State*.....

JENKINS PRACTICAL PIPING LAYOUTS 47

How to plan a

LOCALIZED HOT WATER SUPPLY USING STEAM-COLD WATER MIXERS

Generally small in size (up to 1" or 1½"), steam-cold water mixers are used to supply hot water economically to limited areas in industrial plants—washrooms, chemical processes, sterilizing, heat exchangers. The accompanying diagram shows the installation of two such mixers, with piping connections.

Strainers, in all lines to the mixers, prevent accumulation of scale and dirt, and thus prolong mixer life. Many install a steam trap at the end of the steam feed to drain the condensate away. This keeps live steam at the mixer inlet, and avoids lost time in arriving at desired hot water outlet temperature.

The check valve recommended for this layout is the Fig. 92, Jenkins Regrinding Bronze Swing Check Valve. These checks prevent backup and mixing of the steam and cold water in the feed lines. The Fig. 92, with its 45° seat, will remain tight even at extremely low pressures, and its high tensile strength bronze disc can be reground easily without removing the valve from the line.

Consultation with accredited piping engineers and contractors is recommended when planning any major piping installations.

A CHOICE OF OVER 500 VALVES

To save time, to simplify planning, to get all the advantages of Jenkins specialized valve engineering, select all the valves you need from the Jenkins Catalog. It's your best assurance of *lowest cost in the long run*. Sold through leading Industrial Distributors.

Jenkins Bros., 80 White St., New York 13, N.Y.; Bridgeport, Conn.; Boston; Philadelphia; Chicago; San Francisco; Atlanta. Jenkins Bros., Ltd., Montreal.

A NEW BOOK OF PIPING LAYOUTS, Nos. 26-50 including above, is in preparation. Mail coupon to get your copy when ready.

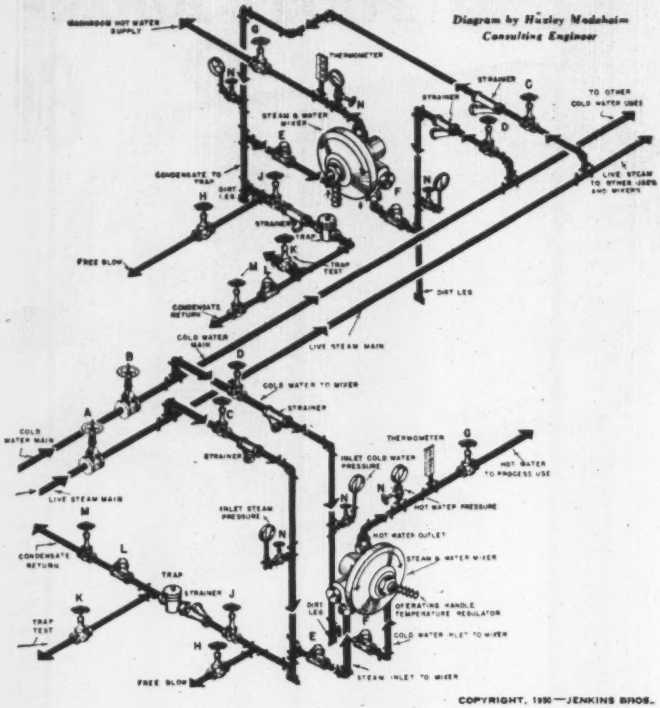
JENKINS BROS., 80 White St., New York 13, N. Y.
Reserve copy of New Piping Layout Book for

Name .....

Company .....

Address .....

.....



COPYRIGHT, 1950—JENKINS BROS.

VALVE RECOMMENDATIONS
For details and valves to suit varying conditions see Jenkins Catalog

CODE	QUAN.	JENKINS VALVES	SERVICE
A	1	Fig. 651 IBBM Gate	Steam Main Shutoff
B	1	Fig. 651 IBBM Gate	Cold Water Main Shutoff
C	2	Fig. 47 Bronze Gate	Steam Feed to Mixer Shutoff
D	2	Fig. 47 Bronze Gate	Cold Water Feed to Mixer Shutoff
E	2	Fig. 92 Bronze Swing Check	Prevent Backflow to Steam Main
F	2	Fig. 92 Bronze Swing Check	Prevent Backflow to Cold Water Main
G	2	Fig. 106A Bronze Globe	Control on Hot Water Outlet
H	2	Fig. 106A Bronze Globe	Emergency Free Blow on Condensate
J	2	Fig. 47 Bronze Gate	Condensate Trap Shutoff
K	2	Fig. 106A Bronze Globe	Trap Test
L	2	Fig. 92 Bronze Swing Check	Prevent Condensate Backflow
M	2	Fig. 47 Bronze Gate	Condensate Return Shutoff
N	6	Fig. 743 Bronze Needle	Pressure Gage Control

JENKINS
LOOK FOR THE DIAMOND MARK
VALVES
SINCE 1864
TRADE JENKINS MARK

• Keep Informed . . .

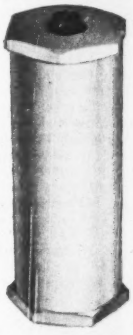
Announcements of current advertisers in MECHANICAL ENGINEERING and A.S.M.E. MECHANICAL CATALOG

• NEW EQUIPMENT
• BUSINESS CHANGES
• LATEST CATALOGS

Available literature or information may be secured by writing direct to the manufacturer and mentioning MECHANICAL ENGINEERING as a source.

• NEW EQUIPMENT

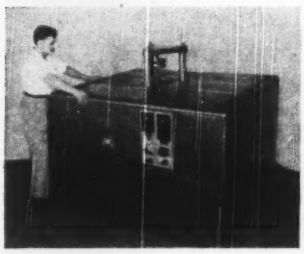
High Pressure Micronic Filter



Waterman Engineering Co. announces the development of an inexpensive high pressure micronic filter for hydraulic systems. This in-line filter is a simplified design of rugged construction and suitable for 3000 PSI operating pressure. Replaceable element filters particles as small as 40 microns. Pressure drop is 25 PSI at 10 GPM flow using SAE 20 oil. Ports are $^3/_4$" N.P.T. (dry seal). For descriptive circular write Waterman Engineering Co., 721 Custer Ave, Evanston, Ill.

New Fatigue Testing Machine

Filling a wide gap in the capacity range of Baldwin-Sonntag Universal fatigue and simulated service testing machines, a new machine of 10,000 lb. total capacity (5000 lb. maximum static preload plus 5000 lb. maximum alternating force), known as the SF-10-U, is announced by The Baldwin Locomotive Works, Philadelphia 42, Pa. This machine applies alternating vertical forces at a frequency of 1800 cycles per minute and maximum amplitude of $^1/_2$ inch. Load accuracy is within 2 percent of load or 0.4 percent of capacity, whichever may be the greater. The machine is driven by a 2 hp synchronous motor.



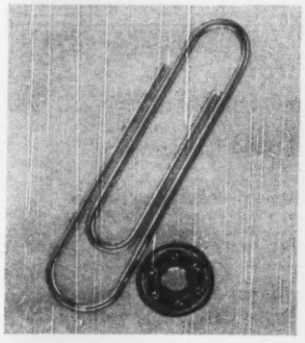
The new fatigue machine operates by the same constant-force principle as other SF type fatigue machines. Dynamic loads are applied by the centrifugal force of a mass rotating at constant speed in an oscillating frame. The force is accurately controlled by varying the distance between the mass and its center of rotation. Inertia forces are compensated by carefully designed springs and calibrated weights.

In addition to the features of other fatigue machines of this type, the new machine will accurately maintain static preloads up to 5000 lb. during tests. Preload is automatically reset to the predetermined value whenever an electrical contact is made by a slight change in the length of calibrated loading springs (induced by creep in the specimen or other cause). A relay circuit then activates a motor to drive preloading screws.

All load-receiving parts are mounted in an inner machine frame which is seismically suspended by springs in an outer frame so that no perceptible vibrations are transmitted to or received from the floor.

The new machine occupies a floor space 59 by 67 inches and its work table is $44^1/_2$ inches high with an area 52 by 60 inches on which to accommodate specimens or full size machine elements or assemblies.

Major Development in Anti-Friction Bearings



Reported to represent a 33% reduction in size from the smallest of its type previously available in this country, the new "Micro" Ball Bearing number R 1-4 (pictured here), of Conrad (retainer) design, is said to reduce friction by $^1/_3$ compared to the next larger size, with a similar 33% reduction in internal surface speeds, increasing the speed limit by half; cuts weight and space requirements by 70%, reduces centrifugal forces 80% and moment of inertia, or flywheel effect, 86%.

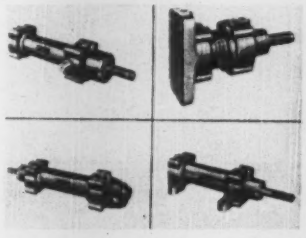
The bearing is fully ground, consistent with precision bearing practice, measuring $^1/_4$" outside diameter by $^1/_{16}$" wide, with a bore diameter of $^1/_{64}$", both diameters being held to tolerances plus zero, minus .0002" (two ten-thousandths inch) from the nominal.

The retainer, or separator, often considered the heart of this type, is of pressed and hardened beryllium-copper, with a tensile strength of 180,000 pounds per square inch as against 40,000 for the usual pressed steel type, and with similar superiority in fatigue and wear-resistant qualities.

Developed over a period of three years by New Hampshire Ball Bearings, Inc., of Peterborough, N. H., immediate uses of this bearing are reported to be chiefly in the fields of Instrumentation and Control, particularly in widely used "Synchro" and "Servo" devices, with the potentialities in small mechanisms in general considered unlimited.

Series LA Hydraulic (Oil) Cylinders

A new and extensive line of hydraulic (oil) cylinders for industrial service, is announced by Vickers, Inc., 1500 Oakman Boulevard, Detroit, Mich.



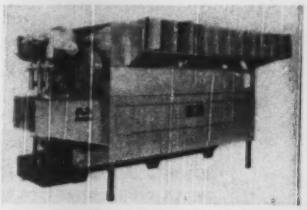
Features of the new cylinders include improved cylinder head seals, multiple piping connection positions, universal mounting positions, special self-adjusting packings, and adjustable hydraulic cushions. Design of the new cylinder line also follows practice recommended by JIC Hydraulic Standards for Industrial Equipment.

The Vickers Series LA Hydraulic (Oil) Cylinders are available in 12 standard bores from 1" to 8", and 12 standard mounting arrangements, with innumerable combinations possible. Nearly all models can be optionally equipped with either standard or heavy duty rods.

For complete information write for Bulletin 49–55.

Spray Fan Coolers

Niagara Blower Co. announces a new series of Spray Fan Coolers for convenient installation in refrigerated rooms where high capacity is required but ceiling height is restricted.



In the new "Low Head Room" design the fan section is located on the side of the unit instead of on its top as in conventional practice. The air enters the spray section

Continued on Page 42

S.S. White

FLEXIBLE SHAFTS SIMPLIFY DESIGN

When power has to turn corners

Courtesy LeJay Mfg. Co.
Minneapolis, Minn.

This cutaway view of the propeller drive on an outboard motor shows how easy it is to run power around a turn with a single S.S.White flexible shaft—much simpler and more economical than with gears, universal joints, etc.

Simplicity is an inherent characteristic of S.S. White flexible shafts. Since they function as a single, self-contained mechanical unit, they are an economical and effective way to simplify your controls and drives to save parts and speed up assembly and production.

WRITE FOR BULLETIN 4581

S.S.White MAKES IT RIGHT

It contains basic information on flexible shaft selection and application. Included are tables of sizes and physical characteristics. Write for a free copy today.

S.S.WHITE INDUSTRIAL DIVISION
THE S. S. WHITE DENTAL MFG. CO. — DEPT. L, 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS AND ACCESSORIES
MOLDED PLASTICS PRODUCTS—MOLDED RESISTORS

One of America's AAAA Industrial Enterprises

• Keep Informed

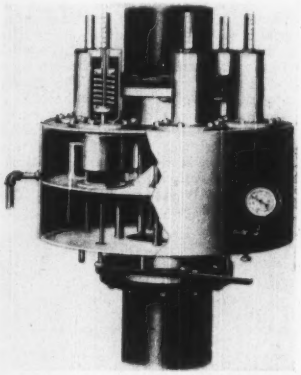
at the top; it is chilled in passing down thru the spray and over the refrigerant coils; it enters the fan section at the bottom and is discharged from the side at the top. When refrigerant temperatures below freezing are used, the process is kept free from frost, ice, or from freezing by the use of brine or Niagara "No Frost" Liquid in the sprays.

The application is to food freezing and storage, meat packing, ice cream hardening, candy chilling, cooling and freezing tunnels and other refrigerating processes. Five unit sizes are produced at present, with capacities ranging from 1680 to 11,000 C.F.M. of chilled air. The maximum height is 72". Floor space required ranges from 16 sq. ft. to 72 sq. ft. Because of improved efficiency in air travel, experience shows that this new type cooler delivers more air at lower power consumption than do conventional vertically arranged coolers. Patents have been applied for. The manufacturer is the Niagara Blower Co., 405 Lexington Ave., New York 17, N. Y.

New Multiport Back Pressure and Relief Valve

A new back pressure valve has been developed and placed in production by Klipfel Valves, Inc., Division of Hamilton-Thomas Corp., Hamilton, Ohio. Made in two types, the new value is exceptionally accurate and durable. Type 135VW will maintain steam pressure at any desired point between 0 and 20 psi; Type 136VW is an atmospheric relief valve for vacuum service. Both valves are suitable for heating systems, power plants and process applications where close regulation of large quantities of steam is required.

The new multiport valve is a logical development of the patented Klipfel No. 135 back pressure valve used so successfully by so many steam users. The multiport valve is fundamentally an assembly of several of these single port valves.



The inner valve consists of an inverted cup which slides on a piston cast integral with the valve seat. Inlet pressure enters the chamber between the cup and piston through a restricted opening in the center of the piston. The narrow seating edge of the cup eliminates nearly all the venturi effect of high velocity steam which is the prime cause of poor regulation and chattering; in addition, the restricted opening into the cup chamber makes it an effective dashpot.

Excellent regulation of inlet pressure from closed to full open valve position is accomplished by several important means. The spring is unusually long; its several inches of initial compression minimize increases in

• Keep Informed

spring tension due to valve lift. The effective area of the cup type inner valve is constant at all positions of valve opening. Finally, the velocity head of the steam flowing through the valve is used to increase the static pressure in the cup, overcoming the small change in spring tension as the valve approaches full open.

With these new back pressure valves, "wire drawing" and "hunting" with pulsating flows are virtually eliminated because the individual valve units can be set to open in sequence. Thus, at small increments of pressure, only one valve at a time is in a throttling position.

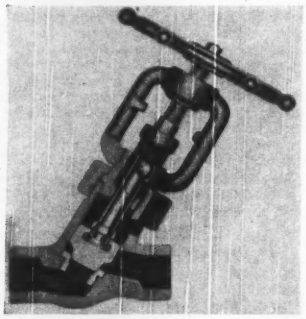
Individual and positive testing or setting of each valve unit can be done without dismantling the valve. Moreover, repairs or replacement of one of the units does not prevent operation of the valve as a whole.

This very practical feature is possible because the units are independent of each other and because the large capacity of the valve permits operation without one of the units.

Welded, all-steel construction of the valve body provides strength with a minimum of weight; all vertical loads are carried by struts to prevent distortion of any part of the valve. For installations requiring frequent adjustment or water sealing, suitable accessories are available.

For further information and complete data, write to Klipfel Valves, Inc., Division of Hamilton-Thomas Corp., Hamilton, Ohio.

New Edward All-Purpose Forged Steel Stop Valves Simplify Maintenance



East Chicago, Ind.—A new line of forged steel stop valves built by Edward Valves, Inc., East Chicago, Ind., can be successfully installed in almost any service where small OS&Y steel globe or angle valves are used. These all-purpose valves, identified as the Fig. 444 series, were designed to fill the need for steel stop valves with wide applicability, good service characteristics, ease of repacking, and a reduced pressure loss.

Swing bolted packing glands and large packing chambers make any necessary repacking extremely simple. Interchangeability of parts greatly reduces maintenance inventories. Bronze yoke bushings prevent galling or freezing of stem.

Constructed of drop forged steel for greater strength, they are available with bolted or union bonnets in sizes ¼ in. through 2 in. and with screwed or socket welding ends. Built of carbon or chromium molybdenum steel for two ranges of service conditions, they are rated for 600 lb at 900°F and 1500 lb at 850°F for steam, oil, and gas service.

These all-purpose valves are now available for shipment from stock in most sizes. Write for free Bulletin 501 for more details.

Continued on Page 44

Grooming the Horses TO RIDE IN THE MONEY

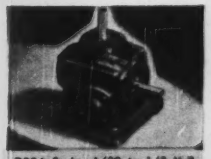
You needn't be concerned with horses, real or mechanical, to profit from the experience of a roving amusement ride operator in Michigan.

He liked to give the youngsters a real whirl for their money. But he couldn't make money when the spinning horse carts broke down or when the kids were so jolted by abrupt starts that they were afraid to ride. Operating difficulties were spoiling the fun — and the profits.

At wit's end, the troubled operator called in Winsmith. It turned out to be true that a stock Winsmith reducer fit the job as a nut fits a bolt. But what really brightened the profit picture were the transmission improvements recommended by the Winsmith factory trained engineer who called. Effected at a negligible cost, they accomplished smooth, low-torque starting, permitted discarding of unpopular safety belts and eliminated shaft breakages. No more profit losses — the mechanical steeds now ride in the money.

Your applications of power transmission may be remote from the amusement field. They may call for large, heavy duty speed reducers to operate sewage sludge agitators, or for fist-size units to rotate a glittering array of appliances on a display table.

Whatever the use, it's worth remembering that with Winsmith you get *widest* selection of stock reducers anywhere — and at the *lowest* cost. But what the ride operator remembers most about Winsmith is what will impress *you* the most from your very first contact . . . unique individualized service by factory trained transmission engineers.

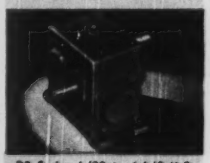


DSRA Series 1/20 to 1/8 H.P.

BV Series 1/3 to 12-1/2 H.P.

BT Series 1/3 to 12-1/2 H.P.

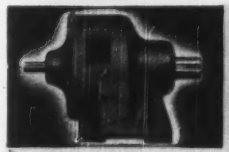
B Series 1/3 to 12-1/2 H.P.



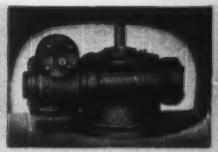
DB Series 1/30 to 4-1/2 H.P.

CATALOG HANDBOOK No. 148

If you have it, get your name on the mailing list for new 1950 edition by writing today.



Ptd. Differential 1/10 to 81-1/2 H.P.



BDV Series 1/100 to 4-1/2 H.P.

BX Series 7/8 to 8-1/2 H.P.

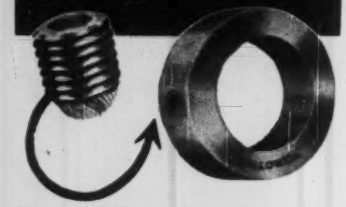
WHS WINSMITH SPEED REDUCERS

WINFIELD H. SMITH CORPORATION

333 JUNE ST., SPRINGVILLE, ERIE COUNTY, NEW YORK

HALLOWELL

Steel Collars



HALLOWELL Solid Steel Collars, functionally proportioned throughout . . . precision-machined so faces run perfectly true . . . are beautifully polished all over . . . yet they cost less than common cast iron collars. 3" bore and smaller are made from Solid Bar Stock. To make sure the collar won't shift on the shaft, they are fitted with the famous UNBRAKO Knurled Point Self-Locking Socket Set Screw—the set screw that won't shake loose when once tightened. HALLOWELL . . . a "buy word" in shaft collars . . . available in a full range of sizes for IMMEDIATE DELIVERY.

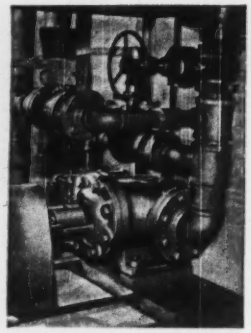
Write for name and address of your nearest HALLOWELL and UNBRAKO Industrial Distributors.

OVER 47 YEARS IN BUSINESS

STANDARD PRESSED STEEL CO.

JENKINTOWN 80, PENNSYLVANIA

Chicago • Detroit • St. Louis • San Francisco



SILENT ELEVATOR SERVICE

made possible by IMO OIL PUMP

This quiet, reliable, pulsation-free, vibrationless pump is just the thing for hydraulic elevator operation—or any other service where noise is a nuisance and reliability is essential.

De Laval-IMO pumps are available for general handling of oil and fluids over a wide range of viscosities.

Send for Catalog LE-A

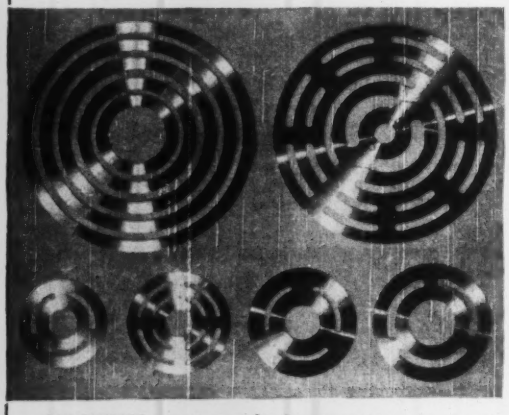
IMO PUMP DIVISION of the

DE LAVAL STEAM TURBINE CO.

TRENTON 2, NEW JERSEY

Voss VALVE PLATES and DISCS

FOR COMPRESSORS



ANY DESIGN • ANY SIZE • INDIVIDUALLY CUT AND GROUND

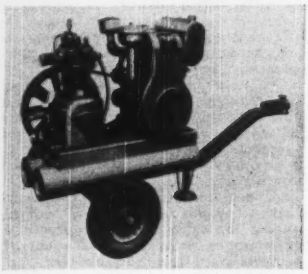
MACHINED—*not punched out*—which prevents cracks and strains thus eliminating breakage risk of fragments of broken plates getting in cylinders. Best obtainable alloy steels used to meet requirements. Oil hardened and tempered to correct hardness. Precision ground to perfect flatness.

Let VOSS make your next Valve Plates and Discs!

J. H. H. VOSS CO., Inc. 785 East 144th Street NEW YORK 54, N. Y.

• Keep Informed

Trailer-Mounted Portable Compressors Designed for Easy Handling



A new line of easily handled trailer-mounted portable compressors has been developed by Gardner-Denver Co., Quincy, Illinois. Designed especially for operating small air tools on miscellaneous service jobs, these new compressor units are said to be ideal for painting contractors, stone masons, monument workers, public utilities and industrial plants. Their capacity is ample for operating paint spray guns, chipping hammers, light paving breakers, spaders, tampers and similar pneumatic equipment.

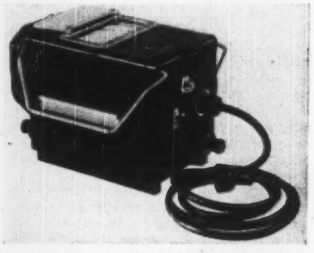
The Gardner-Denver trailer-mounted units are furnished complete—the air-cooled compressor, with V-belt drive to gasoline engine, mounted on a sturdy pipe tank type base. The unit is equipped with semi-pneumatic rubber tired roller bearing wheels, drawbar, trailer hitch and stabilizer leg—can be readily towed behind a car or service truck.

The compressor is built to the same high standards of quality, the manufacturer reports, which have made the larger Gardner-Denver compressors famous throughout industry, mining and construction. The forged steel crankshaft, for example, is supported on both sides of the throw by adjustable Timken Tapered Roller Bearings.

Three sizes are available, and all units are carefully balanced for one-man handling.

Production Line "Megger" Insulation Resistance Tester

Electrical manufacturers and electrical repair shops will find the new rectifier-operated "Meg" type of "Megger" Insulation Tester a boon to production testing of countless types of electrical equipment. Accurate and dependable tests can be made quickly and easily, thus minimizing defective merchandise and possible hazard.



Other important uses for this new instrument include: 1—Testing control circuits and other equipment in power plants. 2—Testing extensive lighting and power installations. 3—Testing generators, cables and other equipment in which the dielectric absorption effect is significant. Such tests

• Keep Informed

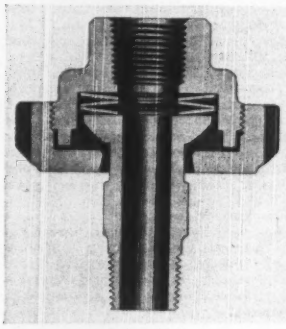
involve careful observations of insulation resistance with time up to 10 or more minutes. 4—Testing multi-conductor communication cables, as in telephone plants. 5—Testing control and power circuits in railway signal installations. 6—Production testing of all types of electrical equipment and components. 7—Experimental and laboratory use.

In the Rectifier-Operated "Meg" instrument, the hand generator is replaced by a "power-pack" consisting of a constant-voltage step-up transformer and selenium rectifier, giving a constant d-c test voltage. The "Megger" true ohmmeter, covers a wide range and is independent of supply voltage.

Complete information and prices may be had by requesting Bulletin 21-46-50 from the James G. Biddle Co., 1316 Arch Street, Philadelphia 7, Pa.

New Low Torque Rotary Swivel Joint

The Barco Manufacturing Co. has announced a new rotary swivel pipe joint for swivel and slow-revolving applications.



The design of this joint eliminates wedge action of the ball against the gasket, thus turning torque is almost completely eliminated. The ball is held in place by a Belleville spring.

It is unique among swivel and revolving joints in that a small amount of side flexibility reduces the possibility of wear or breakage from side strain.

It performs without leakage at extreme temperatures and extra heavy models are available for extreme pressures and vacuums.

Successful performance has been obtained at continuous rotation up to 30 RPM. It will handle practically all fluids and gases including corrosive acids and alkalis.

Simplicity of design permits low first cost and freedom from maintenance.

Presently available in 90° angle and straight designs in $^3/_8$" to 1" pipe sizes. For information, write Barco Manufacturing Co., Dept. 73, 1801 West Winnemac, Chicago 40, Ill.

York Offers Shangri-La Comfort to Public

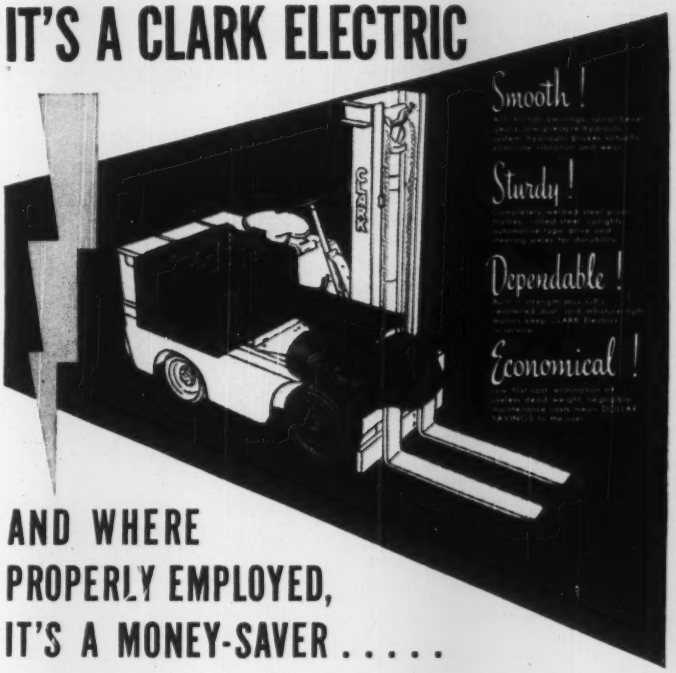
It's here at last! Air conditioning that would be perfect even in Shangri-La, claim York Corp. Development Engineers.

They say this is no idle boast. Offered for the first time on the 1950 market, York has announced that its Yorkaire Models 352 and 552 have been equipped with an "atmostat" which they claim gives new comfort with atmospheric control.

York Engineers are quick to point out that this is the most ultra-advanced development in packaged air conditioning units in the last

Continued on Page 46

IT'S A CLARK ELECTRIC



AND WHERE PROPERLY EMPLOYED, IT'S A MONEY-SAVER . . . . .

Profitwise, it makes no difference to CLARK whether you choose electric-powered or gas-powered fork-lift trucks; CLARK builds a complete line of *both*. But profitwise, it makes an important difference to *you*.

The benefits to be gained from mechanizing your materials handling are sure to be considerable under any circumstance, but they can be maximum *only* when you use equipment that is *exactly right* for your particular operation. By determining *before you buy* which power type is better for your plant, you'll be money ahead . . . and more money ahead, of course, for buying that proper power type in the CLARK line.

You can CONSULT CLARK with assurance of getting completely impartial advice about your specific needs; advice backed by unrivalled experience in modern materials handling methods, and by machines that are acknowledged leaders in their field.

It will pay you to call the CLARK dealer. There's one near you, and he's equipped to give you thoroughly dependable help. It costs nothing to CONSULT CLARK and it doesn't obligate you in any way.

For a copy of Material Handling News and information about CLARK movies (invaluable guides to the best in materials handling methods and machines) write direct to CLARK.

CLARK ELECTRIC AND GAS POWERED FORK TRUCKS AND INDUSTRIAL TOWING TRACTORS

INDUSTRIAL TRUCK DIV., CLARK EQUIPMENT COMPANY BATTLE CREEK 88, MICH.
REPRESENTATIVES IN PRINCIPAL CITIES THROUGHOUT THE WORLD
AUTHORIZED CLARK INDUSTRIAL TRUCK PARTS AND SERVICE STATIONS IN STRATEGIC LOCATIONS

All These Were Once

DUST COLLECTION PROBLEMS, TOO

48 Carbon Black Plants
203 Metallurgical Installations
205 Acid Plants • 40 Paper Mills
270 Detarring Installations
216 Power Stations
73 Steel Plants • 99 Oil Refineries
and Miscellaneous Installations

Your electrical precipitator installation will be individually engineered...and based on the Research Corporation's *experience* graphically shown by that towering pile of thousands of blue prints.

This knowledge is a valuable asset that will help Research engineers to "tailor-make" your Cottrell installation. For example, they can more quickly determine the right answers to such variables as the size, shape and type of both discharge and collecting electrodes, their relative spacing, flue arrangements and many other factors. At Research you can count on *profitable solutions to individual problems.*

Research Corporation Cottrells can be made as efficient as you desire. They can collect 95% to over 99% of all solid or liquid particles suspended in gas entering equipment. Write for free booklet giving valuable data. RC-121

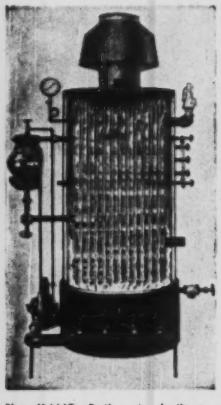
Typical One Day Collections

• 250 TONS OF FLY ASH
• 5500 POUNDS OF CONCENTRATED SULPHURIC ACID
• 6 TONS OF SODA SALTS AT PAPER MILL

RESEARCH CORPORATION

405 Lexington Ave., N. Y. 17, N. Y. 122 S. Michigan Ave. Chicago 3, Ill.

STEAM —AS YOU WANT IT... WHERE YOU WANT IT



The KANE Boiler is built to A.S.M.E. specifications, in sizes to 30 H.P.

THE KANE BOILER PACKAGE

Each KANE BOILER PACKAGE is carefully considered by us as an "individual" job,—from the customer's requirements to the finished unit. And each BOILER PACKAGE is a compact, self-contained steam source that includes: the correctly sized KANE Automatic Gas-Fired Boiler complete with gas burner and controls to maintain required steam pressure, and an M-K-O Automatic Boiler Feed system designed to return condensate and supply make-up water as required for highest operating efficiency.

Engineered Steam at its best with four decades of experience at your disposal—so, send your steam problem to us for study and recommendation.

ENGINEERED STEAM AT ITS BEST

MEARS•KANE•OFELDT INC.

1903-1915 EAST HAGERT STREET, PHILADELPHIA 25, PA.

FOUR DECADES OF AUTOMATIC GAS-FIRED BOILER MANUFACTURING EXPERIENCE

• Keep Informed

twelve years. Heretofore, they say, packaged air conditioners such as those used in restaurants, stores, bars, offices, theatres, banks, hotels and hospitals were designed to cool and dehumidify the atmosphere at a fixed ratio.

This system, according to them, works ideally under normal conditions. However, conditions are not always normal. York Engineers admit that during those Spring, Summer and Fall days, when the weather is uncomfortably humid, present day packaged air conditioners must chill the air excessively to wring out excess moisture.

However, with the invention of the "atmostat", they claim, it is now possible to balance the atmosphere with a packaged unit that is quickly and easily installed in as little as 23 by 32 inches of floor space.

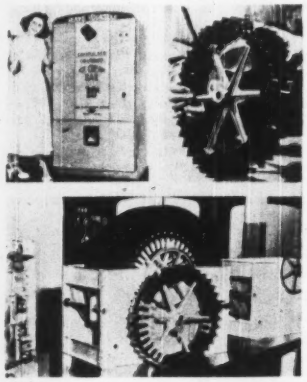
Previously, atmospheric controls were installed only on special engineered central station air conditioning systems where exact temperature and humidity control was a "must," according to the York Engineers.

They say a revolutionary new Air Wringer V-Coil makes the operation of the "atmostat" possible. Under normal conditions refrigerant flows through both sides of the "V" coil. However, under muggy abnormal conditions, all that is necessary to retain ideal atmosphere conditions, they claim, is a flip of the "atmostat" switch. The refrigerant is then diverted to one side of the coil where it is concentrated on removing the excess moisture from the air without reducing temperature below the comfort level. "In short it means, two air conditioning systems in one," they said, "that's why Yorkaire is being called the '2 in 1' air conditioner."

The Yorkaire models, 352 and 552, according to the announcement, have a complete hermetic cooling system that is set, tested and sealed at the factory, tamperproof and trouble-free to assure the same service-free performance of the finest household refrigerators.

Plastic Parts Make Drastic Cut in Vending Machine Production Cost

Use of plastics instead of metal for vita parts of a new ice cream vending machine has cut the production cost $31.3—more than one-third of the machine's retail price.



The new vending machine serves up frozen ice cream pops at the drop of a coin and delivers change when necessary. Its dispensing units hold 148 ice cream pops and are automatically reloaded from the storage space which holds 300 more. The dispensing units are four large gear-shaped rings that turn

• Keep Informed

on a single shaft to deliver pops to customers one at a time.

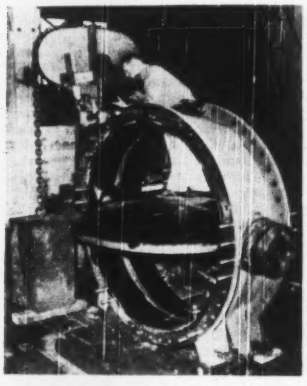
Each dispensing unit ring is composed of two sections molded from Bakelite phenolic plastics material by Plastic Fabricators, Inc., of Fernwood, Del. Co., Pa., who also designed and made the mold. These plastic dispenser units each cost $76 less than a comparable unit of die-cast metal, saving $304 on each vending machine for the joint manufacturers—Eastern Engineering and Sales, Inc., and Dexdale Hosiery Mills. Use of eight shaft bushings molded of Bakelite phenolic plastic and costing six cents each instead of soft metal bushings which cost $1.20 each saved an additional $9.12 per machine.

Laminated plastics made with Bakelite phenolic varnish are also used in the machine for drum facings and spacer bars on the dispenser units because they are strong, light, easy to assemble, dimensionally stable and they won't corrode.

Along with production cost cuts enabling them to sell the ice cream vendor for $895, the manufacturers found other benefits in the shift to plastics. Production was speeded by the elimination of several machining and finishing operations. The machine worked more efficiently. It weighed 30 pounds less, cutting shipping expenses, and the ice cream pops don't stick to the plastic dispensers as they did to the metal.

Westinghouse Builds Big Valves for Southern California Edison

A contract for building two 120-inch butterfly valves for Southern California Edison's Big Creek Powerhouse No. 4 has been awarded to the Westinghouse Electric Corp. The two valves, to be built at the corporation's Sunnyvale plant, will regulate the flow of water to hydro-generators at the powerhouse on the San Joaquin River approximately 52 miles northest of Fresno. Delivery of these valves is slated for the latter part of 1950.



Among other domestic hydraulic valve manufacturing assignments now underway at the Westinghouse plant are 10 large linked roller gates for the Garrison Dam in North Dakota, part of the Missouri Valley project; six sluice gates and three linked roller gates complete with frames and hoists for the Grapevine Dam, Texas; three 54-inch butterfly valves for the Municipal Water District of Los Angeles, and a 30-inch Staats-Hornsby valve for the Los Angeles Flood Control District. The last-named valve, to be installed at Pacoima Dam, discharges water

Continued on Page 48

This nationally known tanner and manufacturer of work shoes and gloves writes us . . .

". . . You recommended to us LUBRIPLATE NO. 100 for lubricating the chain drive on our paddle wheels which turn the hides immersed in a solution in concrete vats. The chain, during use, is always soaked. The solution is sometimes acid and sometimes caustic. Up to the time of your recommendation, we had not found any lubricant that would stay on the chains for any appreciable time.

"Heretofore, the average life of a chain was approximately one year. We have applied LUBRIPLATE to these chains every two weeks for two years. Since then, not one new chain has required replacement, and they are still going strong.

"At this time it appears that *for every dollar we have invested in* LUBRIPLATE, *we have saved seven dollars* in chains with actual savings still to come."

WOLVERINE SHOE & TANNING CORP.
Rockford, Michigan

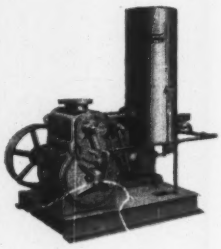
You, too, can enjoy the savings made possible with LUBRIPLATE Lubricants. There is a LUBRIPLATE product for every industry. LUBRIPLATE reduces friction and wear, prevents rust and corrosion and is most economical to use. Write today for case histories of savings made possible by the use of LUBRIPLATE Lubricants in your industry.

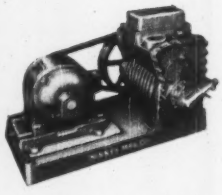
LUBRIPLATE DIVISION • Fiske Brothers Refining Company
Newark 5, New Jersey • Toledo 5, Ohio
DEALERS EVERYWHERE • SEE YOUR CLASSIFIED TELEPHONE BOOK

LUBRIPLATE the Modern Lubricant

Using this test chamber with its Kinney High Vacuum Pump, engineers are now able to create controlled high-altitude conditions right in the laboratory. This artificial "Heaven on Earth", designed and built by Distillation Products, Inc., is a great boon to the aircraft industry. It permits precise observation of what happens to equipment under the extremely low absolute pressures encountered miles above the earth.

On the production line, too, Kinney Pumps are essential to many modern products and processes. Vacuum production of light bulbs and electronic tubes, vacuum coating of mirrors, vacuum dehydration of foods and pharmaceuticals—these and many other operations rely on the dependable low absolute pressures created by Kinney Pumps. For detailed information on the complete line, write for Bulletin V45.





Available in eight Single Stage and two Compound models . . . capacities from 13 to 702 cu. ft. per min. . . . for pressures down to 0.5 micron abs.

KINNEY MANUFACTURING CO.

3582 WASHINGTON STREET, BOSTON 30, MASS.

NEW YORK • CHICAGO • PHILADELPHIA
CLEVELAND • HOUSTON • NEW ORLEANS
LOS ANGELES • SAN FRANCISCO • SEATTLE

Making old things BETTER
Making New things POSSIBLE

FOREIGN REPRESENTATIVES

GENERAL ENGINEERING CO. (RADCLIFFE) LTD.
Station Works, Bury Road, Radcliffe, Lancashire, England
HORROCKS, ROXBURGH PTY., LTD., Melbourne, C. I. Australia
W. S. THOMAS & TAYLOR PTY., LTD.
Johannesburg, Union of South Africa
NOVELECTRIC, LTD. . . . . Zurich, Switzerland

KINNEY HIGH VACUUM PUMPS

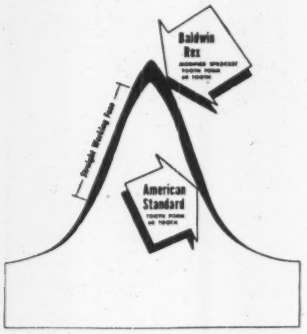
• Keep Informed

in a hollow-jet pattern to minimize erosion and spray in the overflow basin.

Equipment for foreign hydraulic projects now under construction at the plant includes butterfly valves for the Santa Teresa and Danxho Dams in Mexico. Three 72-inch butterfly valves have just been shipped for installation at the Santa Barbara Dam in Mexico.

Baldwin-Rex Improved Tooth Form

Roller chain drive life can be lengthened up to 50% through the proper use of Baldwin-Rex Improved Tooth Form Sprockets. Four exclusive advantages of these sprockets are: (1) All teeth in arc of contact share in the load for the entire life of the chain. (2) The longer tooth form will handle more pitch elongation thereby lengthening the life of the chain. (3) Gap angle is a predetermined variable, designed according to the number of teeth, to assure most efficient chain action. (4) Straight tooth profile permits accurate cutting and finishing of the Baldwin-Rex Improved Tooth Form.



The Baldwin-Rex Improved Tooth Form is composed of a root circle, straight working faces tangent to the root circle and topping curves which bring the tooth to a point. The gap angle, an important feature of tooth design, determines whether or not the power is transmitted by and to all teeth in the arc of contact and whether or not the load on the incoming tooth of the driver sprocket or the outgoing tooth of the driven sprocket is held to a minimum. There is an ideal gap angle for each number of teeth. Too large a gap angle forces the chain out of mesh and allows it to override the sprocket teeth. The minimum gap angle is fixed by a required clearance adjacent to the roller path in entering or leaving the tooth gap. The gap angle of the teeth in a Baldwin-Rex Sprocket is designed for the closest practical approach to the ideal so that the load is best distributed over the teeth in mesh. The pressure angle of Baldwin-Rex Improved Tooth Form Sprocket is variable, but does not change with chain wear. The power is transmitted by and to all teeth in the arc of contact irrespective of any pitch increase due to chain elongation. In addition, the straight working face of the Baldwin-Rex Improved Tooth Form can be accurately finished. The lengthened profile of the Baldwin-Rex Improved Tooth Form allows for more pitch elongation before the chain will fail to properly mesh with the sprocket teeth.

The American Standard Tooth Form, which is now generally in use, is composed of curves on the flank and face. With this design, the pressure angle decreases with chain wear. With a decreased pressure angle, the incoming tooth of the driver

• Keep Informed

sprocket and the leaving tooth of the driven sprocket have more and more of the load imposed upon them. This increases sprocket wear and decreases chain and sprocket life. For sprockets having a medium to large number of teeth, the teeth are too short and do not provide for sufficient chain pitch elongation. This results in the necessity of discarding the chain before it is worn out.

New Line of Temperature Indicators Announced by G.E.

A new line of temperature indicators for industrial and laboratory use has been announced by General Electric's Meter and Instrument Divisions.

Included in the line are cold-end compensated thermocouple thermometers for measuring temperatures up to 3000 F and resistance thermometers for temperatures up to 300 F.

The thermocouple thermometer is available in two sizes: the Type DO-71 with a $3\frac{1}{2}$-inch flange and the DW-71 with a $2\frac{1}{2}$-inch flange. Both types can be supplied in either square or round molded Textolite cases.

The thermocouple thermometer can be used for temperature measurement in a wide variety of industrial applications, including galvanizing vats, melting pots, industrial furnaces, infrared drying ovens, oil quenching baths, ceramic kilns, and salt baths for annealing.

Designed for the measurement of low temperatures where high accuracy is important, the resistance thermometers are available in two standard types: the DB-15 long-scale instruments and the Types DD-6 and DD-six-inch rectangular, surface- and flush-mounted instruments.

These thermometers are suitable for bearing temperature measurement, generator- and transformer-winding temperature indication, refrigeration and air conditioning testing, drying operations, remote fluid temperature indication, and scientific laboratory work.

Abrasion-Resistant Flexible Metal Tubing

Chicago Metal Hose Corp., a leader in the manufacture of Flexible Metal Hose and Tubing for industry, announces an added type "Abrasion-Resistant" flexible tubing to its extensive line.

This "Abrasion-Resistant" flexible tubing is designed specifically for conveying grain, rough forage, slag, insulation and other granular materials. The flexible tubing, fabricated from galvanized steel strip, is of the "fully interlocked" type, incorporating in its construction a galvanized steel strip inner liner as an integral part of the tube. The liner laps over the spaces between the tube convolutions giving a smoother inner surface-free from obstructions. The liner also gives protection to the surface of the convolutions.

Continued on Page 50

THE NEW PRESSURE GAGE IN SQUARE, FLUSH CASE

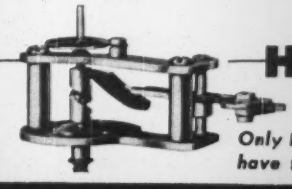
— self-illuminated with black light just like airplane or automobile panel instruments for better visibility without glare

— also available with white light or without illumination

— ideal for symmetrical panel layouts

— dial sizes 4½", 6" or 8½"—all standard pressure ranges

Write for complete information



HELICOID

ACCO

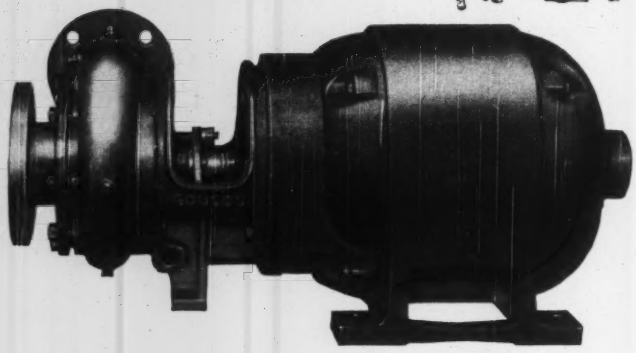
Only Helicoid Pressure Gages have the Helicoid Movement

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE COMPANY, INC.
Bridgeport 2, Connecticut

TRADE MARK

FOR A LOT OF PUMP

IN A SMALL PACKAGE



Goulds "Close-Cupld"

This efficient, advanced design pump gives the operating man many advantages that eliminate liquid transfer problems.

The pump and motor are a compact unit. The single shaft maintains perfect alignment and the unit is vibration free. You don't need a bedplate.

All you do is set the "Close-Cupld" in place, connect it up and turn on the current.

Sizes and Capacities:

We make the "Close-Cupld" in 17 sizes with capacities up to 2000 G.P.M., heads up to 400 ft. depending on capacities.

Send for a free copy of Bulletin 701.1 today. It gives you complete data on Goulds "Close-Cupld" pumps.

MEMBER

Goulds PUMPS INC.
Seneca Falls
New York

• Keep Informed

The abrasion-resistant feature of the flexible tube reduces friction and allows free smooth flow of material being conveyed, with a minimum of clogging and work stoppage. Excessive wear of convoluted joints is eliminated—materially lengthening tube life and producing a savings in maintenance and replacement cost.

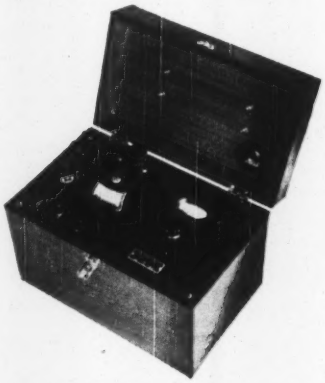
For further information regarding this new type tubing and its many applications, write Chicago Metal Hose Corp., 1305 South Third Ave., Maywood, Ill.

High Speed Rolling Mill for Aluminum Foil

Loewy Rolling Mill, Division of Hydropress, Inc., New York, has received an order for a complete High-Speed Rolling Mill for Aluminum Foil from one of the leading manufacturers in Italy. The installation consists of one 4-High Breakdown Mill and one 2-High Finishing Mill operating at 3000 feet per minute. It will have a production capacity of the thinnest Aluminum Foil of 400,000 lbs. per month. Two similar Rolling Mill Plants which are being built by Hydropress for leading French companies will make France independent of Aluminum Foil imports

New Potentiometer For Corrosion Field Testing

Designed especially for corrosion field work, this new portable potentiometer announced by Leeds & Northrup Co. incorporates features requested by leading corrosion engineers. The instrument makes it possible to obtain fast, accurate, dependable readings over the wide range encountered when investigating galvanic and electrolytic action along pipe lines, cables and other buried metal structures.



Total range of the potentiometer is 0 to 4.1 volts, measurable in one millivolt steps. This range is subdivided into 12 different steps, some of which overlap. Easy-to-use switches and keys make it possible to select the portion of the total range best suited for the problem at hand.

Potentiometer operation has been made as simple as possible. An emf reversing key makes it possible to measure opposite polarities without changing leads. Standardization is not affected by switching the reversing key or changing ranges.

The instrument is ideal for field use. Current is provided by flashlight batteries that are obtainable anywhere. Binding posts are provided for connection to any external 6 volt d-c source when needed. The entire potentiometer, including batteries, galvanom-

• Keep Informed

eter, and standard cell is housed in a sturdy oak case. Weight of the complete instrument including batteries is about 10-1/2 pounds.

For further details, write to Leeds & Northrup Co., 4934 Stenton Avenue, Philadelphia 44, Pennsylvania.

Inspection Course for Railroad Men to be Held by SKF

An intensive two-day course in the service inspection of anti-friction bearing installations in traction motors of diesel-electric locomotives is being inaugurated by SKF Industries, Inc., for railroad personnel who service such engines.

The course is designed, the ball and roller bearing company said, to enable the nation's railroads to increase the efficiency and extend the life of diesel-electric equipment "through the scientific and practical handling of bearings."

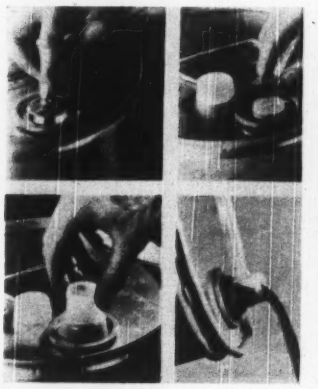
Supervisory personnel of eastern railroads, including shop foremen and superintendents, locomotive inspectors and mechanics, will be the first to attend the course. Initial sessions, limited to 20 persons, were held Dec. 6 and 7 at the company's main plant in Philadelphia.

Representatives of railroads in other sections of the country will be invited to attend future sessions, the company said.

The course, reflecting the rapid rate at which railroads are turning to diesel-electric equipment, is the first ever to be offered by an anti-friction bearing manufacturer.

SKF, which pioneered the application of bearings in diesel-electric locomotives, said a wider knowledge of bearings by railroad men should result in substantial savings in inspection and maintenance costs.

Combination Seal-Spout Cuts Waste

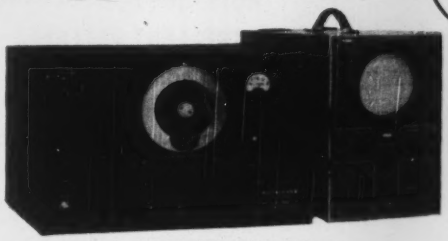


Five gallon pails fitted with this leakproof and tamperproof seal deliver their contents without wasting a drop. Under the metal seal is a pouring spout molded of flexible Bakelite polyethylene which is resistant to most chemicals and solvents, and a threaded cap of the same tough plastic. The shipping seal is destroyed by tearing it off with a knife or similar tool (top left). With the threaded cap off, the airtight seal is broken by cutting out the diaphram molded into the spout mouth (top right). The flexible spout is then pulled out so that it protrudes from the pail, ready for pouring (bottom left). When the

Continued on Page 52

HIGHER ACCURACIES NOW POSSIBLE . . .
SPEED VARIATIONS VERSUS TIME

KAY



THE ROTALYZER

A new instrument for measuring the average rotational speed of a shaft and indicating variations in speed vs time. Provides unusual sensitivity and accuracy over a very wide speed range. The equipment is useful to speed variations of approximately 200 cps. Very small speed variations may be studied.

A high frequency magnetic disc and pickup are employed on the shaft to be measured. A very accurate tunable calibrated local oscillator indicates average shaft rpm in conjunction with a null reading voltmeter. The oscilloscope indicates variations in speed in the vertical direction and time in the horizontal direction.

The standard speed range of the Rotalyzer is 900 to 7200 rpm. This range may be extended upward to 50,000 rpm and downward to 33-1/3 rpm on special order. Accuracy of .1% available over the speed range. Accuracies to .01% available at single speed in standard instrument.

Price: Rotalyzer without oscilloscope $825.00 F. O. B. Factory. Companion Oscilloscope $325.00 F. O. B. Factory. Prices slightly higher outside U.S.A. and Canada.

ELECTRIC KAY COMPANY
14 Maple Avenue Pine Brook, N. J.
Phone CAldwell 4-2000

FAST ON-THE-SPOT REPAIRS
With This Portable Welder!

It's* WISCONSIN *Powered!

This inexpensive "Lincwelder", made by Lincoln Electric Co., Cleveland, O., is easily mounted on running gear or truck for welding service anywhere.

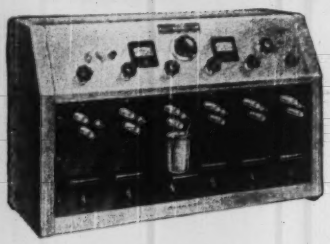
Welding at the breakdown-scene . . . adds up to savings in time and labor with this light but rugged 180 amp. Lincoln Welder, powered by a two-cylinder Wisconsin Heavy-Duty Air-Cooled Engine.

The performance satisfaction of Wisconsin Engine power increases not only the reliability of equipment in all fields, but also increases the confidence of both equipment user and builder. They're sold on such features as self-cleaning, thrust-absorbing Timken tapered roller bearings at both ends of the crankshaft . . . fool-proof air-cooling, from sub-zero to 140° F . . . an easily serviced OUTSIDE rotary type, high tension magneto with impulse coupling, for quickest any-weather starts . . . plus heavy-duty construction, inside and out.

Your investigation is invited! 3 to 30 hp., 4-cycle single-cylinder, 2-cylinder, and V-type 4-cylinder models.

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 14, WISCONSIN

CENCO ELECTROANALYZER



NOTE THESE EXCELLENT FEATURES—

- Separate Controls
- Air Agitation
- Quick-change Electrode Holders
- Built-in Rectifier

No. 26305 Cenco Electroanalyzer gives quantitative measurements of the electrodeposition of metals, quickly and conveniently. Six sets of fixed anode-cathode positions permit simultaneous determinations. Any single station may be quickly removed with the snap of a switch. A selector switch permits reading voltage at any one of six stations. A maximum of 5 amperes direct current can be applied to any or all of the stations. Current flowing through the circuit is controlled by a knob on the front panel. A voltmeter reading 0 to 8, an ammeter, 0 to 5, and separate controls for regulating the air or gas agitation are also mounted on the front panel. A built-in rectifier converts 115 volt, 50/60 cycle A.C. to D.C. with less than ½% A.C. ripple at full load.

Write for Circular 1173

CENTRAL SCIENTIFIC COMPANY

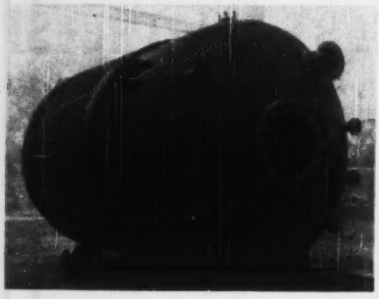
Scientific CENCO Apparatus

1700 IRVING PARK ROAD CHICAGO 13

NEW YORK BOSTON SAN FRANCISCO NEWARK LOS ANGELES TORONTO MONTREAL

SPECIAL TECHNIQUE

KEEPS IRON PICKUP TO A MINIMUM ON THIS NICKEL CLAD JOB . . .



The above photo is of a dissolving tank 8'6" O.D. x 11'0" long, of straight, 20% Nickel Clad, and testing at 75 lb.

In welding nickel clad steel, our experience has taught us that the choice of the proper welding rod, proper fitting, number of beads, protection of surfaces during fabrication, are important factors to assure a satisfactory job.

Our Welding Engineers and Technicians have given the above factors considerable study and we have arrived at conclusions which we firmly believe assures a quality job.

It is true that our procedures result in a higher initial cost, but for service the additional expense involved should prove to be good insurance.

Your inquiries for pressure vessels of Nickel Clad, Stainless, Stainless Clad, Carbon Steel, are solicited. Another important factor of our business is the design and fabrication of Heat Exchanger Equipment.

NEW YORK OFFICE: 30 CHURCH STREET

DOWNINGTOWN IRON WORKS

DOWNINGTOWN, PA.

WELDED and RIVETED PRODUCTS

• Keep Informed

liquid is about to be poured, it can be seen through the translucent spout, which also helps prevent spilling and waste by confining the flow (bottom right). Furnished on both lug-covered and tight-headed pails, the seal-spouts are crimped on the latter in a single operation after the pails have been filled. The closure withstands greater internal pressures than the pail itself, and a filled pail can be dropped six feet on the seal without breaking it, according to the manufacturer.

Molded of Bakelite polyethylene, this combination seal-spout for five gallon pails is manufactured by Rieke Metal Products Corp., Auburn, Ind. These Flex-Spout closures are sold to pail manufacturers who, with Rieke dies, make the filling hole in the pail cover and the embossment to receive the closure. Thus, the pail, including the closure, is priced by the pail manufacturer.

Rotary Booster Ammonia Compressors

A rotary booster ammonia compressor for use in low temperature applications such as ice cream manufacturing, packing plants, and the quick freezing of food products, was recently announced by York Corp., York, Pa.

The York rotary booster compressors are especially suitable for increasing economically the capacities of existing low temperature systems where requirements have grown beyond the capacities of the plant. Booster compressors are installed on the lowside in series with the high-stage compressor. They provide capacities ranging from a few tons up to 250 tons in a single compressor.

The operation of the York booster compressors is such that they always start unloaded so that special high torque motors are

Do you know that every year thousands of plants are made **SAFER MORE COMFORTABLE MORE EFFICIENT**

IRVING GRATINGS

(OPEN STEEL MESH FLOORING)

IRVING "DUPLEX" GRATING IN ANNEALING PLANT

• WRITE FOR CATALOG

IRVING SUBWAY GRATING CO., INC.

ESTABLISHED 1902

Home Office and Plant: 50th & 27th Street, LONG ISLAND CITY, N.Y.

Western Division: Foot of Park Ave., CHICAGO

WORKS WHERE OTHERS WON'T

accurately formed

GRAPHALLOY
OILLESS
BEARINGS

SPECIFY GRAPHALLOY
TRADE MARK REG. U. S. PAT. OFF.
WITH CONFIDENCE

SELF-LUBRICATING ○ EXTREMELY DURABLE ○ CONSTANT CO-EFFICIENT OF FRICTION ○ OPERATES DRY — OR SUBMERGED IN WATER, GASOLINE OR CORROSIVE LIQUIDS ○ APPLICABLE OVER A WIDE TEMPERATURE RANGE — even where oil solidifies or carbonizes ○ EXCELLENT AS A CURRENT-CARRYING BEARING.

GRAPHITE METALLIZING CORPORATION
1058 NEPPERHAN AVENUE, YONKERS 3, NEW YORK

• Keep Informed

not necessary. Motor selection is governed by the pulldown requirements on the job, and normal torque motors are satisfactory for all applications.

York has been using similar compressors in connection with F-22 and F-114 refrigerants for a number of years, and the addition of the ammonia equipment is a natural development and expansion of this efficient equipment into other fields.

Mercury Thermal System for High Temperature Applications

A newly developed 1200°F Mercury Thermal System for industrial processing has been announced by Taylor Instrument Companies, Rochester, N. Y.

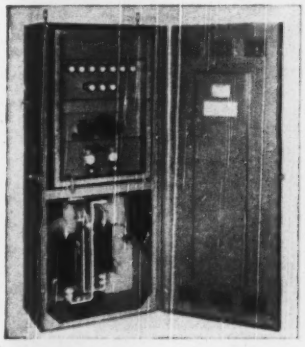
This new Mercury Thermal System provides simple, dependable and less expensive means of measurement and control of temperatures above the conventional 1000°F indication. Such applications as gas-fired ovens, annealing ovens, high temperature blanchers, measurement of exhaust gases and others can be accurately served with this new measuring system.

Outstanding features include a newly developed Bourdon Type spring, Type 347 stainless steel thermal element, compensation for varying case and ambient temperatures and uniformly graduated charts. Range spans of 1000°F, 600°F, and 400°F, or equivalent Centrigrade are available in all standard Taylor indicating recording and controlling instruments. No system can be furnished in which the range starts at temperatures below 700°F.

For further information, write Taylor Instrument Companies, Rochester 1, N. Y.

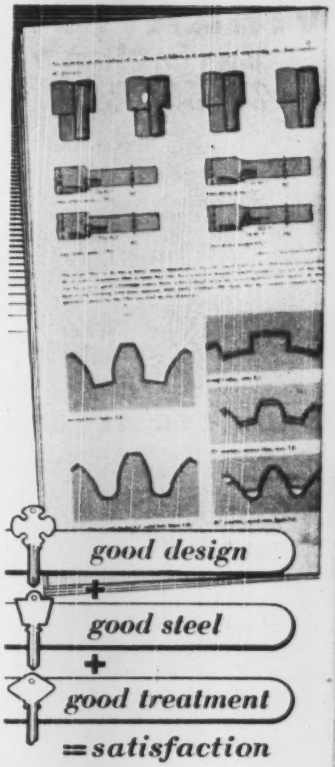
New Electronic Resistance Welding Control Equipment

Two new, all-electronic, high-speed resistance welding control equipments, for synchronous and non-synchronous operation, are available from Westinghouse Electric Corp. The equipments have no moving parts in power and control circuits except initiation and solenoid relays, offering advantages in weld quality, welding costs, and ease in which welds are produced.



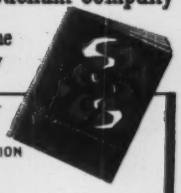
Basic control panels consist of the plug-in Rectox rectifier tube firing panel (for non-synchronous units) or a heat-control firing panel (for synchronous units). These basic controls include also the 3-B sequence weld timer, which controls squeeze time, weld time, hold time, and off time for a single impulse spot welding. It provides non-synchronous timing with repeat and non-repeat control and non-beat control. The substitution of a precision weld-time panel for a 3-B or 5-B

Continued on Page 54



If you are a design engineer seeking success with steel components, you will find help towards your goal on every page of this 72 page booklet. Write now for "3 Keys to Satisfaction"—it is valuable and it is free.

Climax Molybdenum Company
500 Fifth Avenue
New York City



Please send your
FREE BOOKLET
3 KEYS TO SATISFACTION

Name.....
Position.....
Company.....
Address.....
ME 2

F20

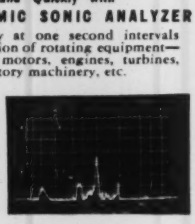
VIBRATION
Variation
Visibly Read

ONCE PER SECOND

LOCATE NOISE AND MECHANICAL TROUBLE
Easily and Quickly with
AP-1 PANORAMIC SONIC ANALYZER

Analyses Visually at one second intervals Noise and Vibration of rotating equipment—gears, bearings, motors, engines, turbines, blowers, fans, factory machinery, etc.

INDICATED AUTOMATICALLY BY VISUAL SPECTRUM SCANNING



Ideal for Production Line

The AP-1 Panoramic Sonic Analyser in portable enough for field or spot work or can be set up permanently in the production line. Visual spectrum scanning screen can be readily compared with standard pattern. Simple to operate—automatically and visually portrays frequency and relative amplitude of noise and vibrational components—eliminates tedious, complicated point-by-point frequency checks.

More and more engineers have discovered the overall advantages of the AP-1 for examining the vibrations associated with rotating equipment, particularly equipment that tends to hunt in speed. Learn what it can do for you.

These instruments are backed up by over 15 years' experience in developing and pioneering panoramic spectrum analyzers.

WRITE FOR FURTHER INFORMATION

PANORAMIC RADIO PRODUCTS INC

• Keep Informed

sequence weld timer provides synchronous precision control when the heat control panel is used.

These combinations are sufficient for many common resistance welding control requirements. However, space is also provided for the addition of auxiliary control panels to meet specific requirements. These auxiliary control panels, easily installed in the equipment, include—a-c forge timer, d-c precision-type forge timer, wave-shape control, voltage compensator, initial-squeeze attachment, current regulator, temper sequence weld timer, dual weld attachment, interlocking relay attachment (enables use of one welding control with two welding machines), dual weld interval attachment, and a "Timatic" control attachment.

The cabinet housing this equipment provides ample room for installation and servicing the ignitron tube firing panel, the sequence weld timer panel, and auxiliary control panels, as required.

For further information write Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

New Instrument Warns Against Air Pollution by Sulfur Dioxide

Industrial plants which discharge gases containing sulfur dioxide can be warned against atmospheric pollution by means of a new automatic analyzing equipment. Developed by Dr. M. D. Thomas of American Smelting & Refining Co. (U. S. Patent 2,462,293), the equipment employs a thoroughly field-tested principle, and is now available for the first time as a complete assembly manufactured by Leeds & Northrup as the Thomas Autometer. This equipment continuously records actual concentration of sulfur dioxide in parts per million; and, as further evidence of accuracy of measurement, it also records average concentration integrated over a half hour period, automatically checks its "zero reading" every thirty minutes, and marks off each cubic foot of air sampled.

Usual range of the equipment—0 to 5 parts SO_2 per million—covers the concentrations which are of interest in pollution surveys. Changes in concentration as small as a few tenths of a part per million can be readily detected.

Unlike most gas-analyzers, the Autometer makes use of electrolytic conductivity as a means of measurement. A continuous

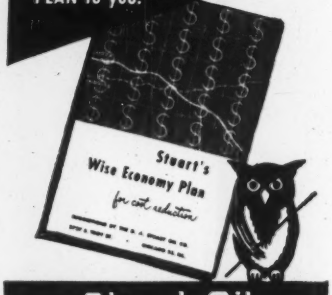
REDUCED MACHINING COSTS RESULT FROM WISE SELECTION OF CUTTING FLUIDS

•

STUART'S WISE ECONOMY PLAN provides the method

Not just another spot check "oil survey," the Stuart plan is a scientific appraisal of a plant's over-all needs coupled with *practical* suggestions and followed through with a continuing technical service.

Ask to have a Stuart Representative explain the WISE ECONOMY PLAN to you.



D.A. Stuart Oil CO.

2741 S. Troy St., Chicago 23, Ill.

• Keep Informed

sample of air is passed through a solution which absorbs SO_2, causing a change in the electrolytic conductivity of the solution.

The recording instrument is a Micromax recorder of the same basic type as those which are used in thousands of other industrial applications. It requires only nominal attention consisting of occasional oiling, cleaning, and replacement of ink and chart.

For further information, write to Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

New Improved W-22 (AWS Class E 6010) Arc-Welding Electrode Announced by General Electric

A new improved arc-welding electrode, the W-22 (AWS Class E 6010) a reverse polarity d-c rod, has been announced by General Electric's Apparatus Department.

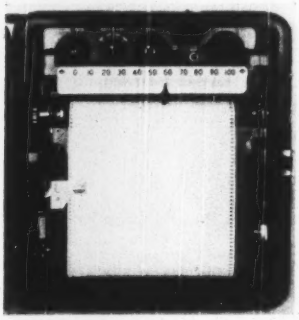
The new W-22 electrode is designed specifically for vertical and overhead welding of all types of joints in mild steel. Because of its penetrating arc the W-22 is suited for welding galvanized plate stock. This penetration also facilitates the welding of lap joints and edge welds.

High tensile strength and ductility with good impact resistance are featured properties of the W-22 electrode welding bead. The new electrode may be used for the repair welding of castings, because of its low volume slag-forming characteristics.

The stable arc produces weld deposits of very smooth contour in horizontal and overhead positions without the necessity of oscillation.

Strain Recorder

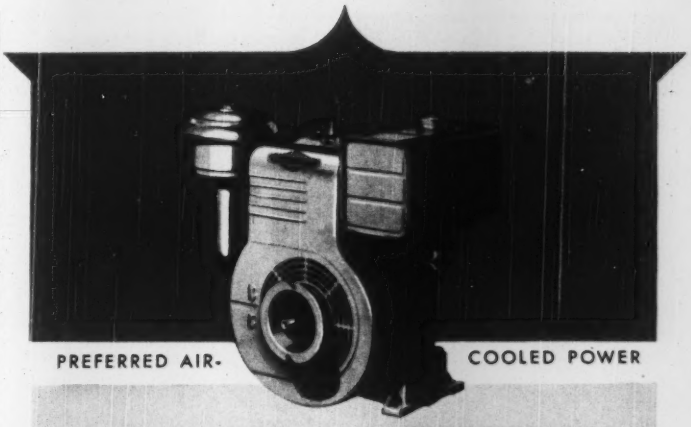
A new strip-chart strain recorder for use in stress analysis with SR-4® bonded resistance wire strain gages is announced by The Baldwin Locomotive Works, Philadelphia 42, Pa. Features of the new recorder are easy readability with a 9½-inch wide chart scale, two chart speeds of 6 and 180 inches per hour, and accommodations for a two-arm and four-arm strain bridge. Slowly varying strains can be recorded for as long as 10 days without changing the chart.



The instrument is a special adaptation of the Leeds & Northrup Speedomax Type G, Model S recorder with simple adjustments for strain gage characteristics, strain ranges, and for the Wheatstone bridge circuit. Basically the circuit is a DC potentiometer type for measuring the output of a strain gage bridge. A DC power supply is built into the recorder and a voltage regulator is supplied separately.

An important feature of the circuit is the arrangement for directly standardizing the

Continued on Page 56



It's Powered "RIGHT" when It's Powered by

BRIGGS & STRATTON

•

Designed "Right" — Built "Right"
The Preferred Power of
Users, Dealers and Manufacturers

•

The reputation for "dependable" performance established by more than 4 million engines, during a period of over 30 years, has placed Briggs & Stratton as first choice in the field — the "Preferred Air-Cooled Power" the world over.

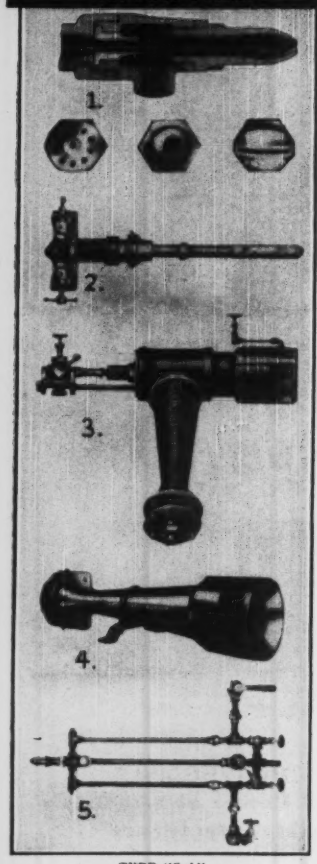
Let the Briggs & Stratton trademark be your guide to all that is best in 4-cycle, single-cylinder air-cooled gasoline engine performance.

BRIGGS & STRATTON CORPORATION
Milwaukee 1, Wisconsin, U. S. A.

•

4 CYCLE
BRIGGS & STRATTON
GASOLINE ENGINES
Preferred Power
FOR INDUSTRIAL CONSTRUCTION RAILROAD AND FARM EQUIPMENT

THE *RIGHT* OIL BURNER OR GAS BURNER *FOR YOUR JOB*



TYPE "S-A"

1. (For use where steam is available) *atomizes thoroughly* and *burns completely*, the lowest and cheapest grades of fuel oil and tar, requiring only low oil pressure and temperatures.

TYPE "S-A-L"

2. (Large capacity burner similar to TYPE "S-A-R") is adaptable in combination with powdered coal burners in large boilers.

COMBINATION GAS AND OIL BURNER

3. —the "AIROCOOL" Gas Burner in combination with a TYPE "S-A-R" Oil Burner.

"AIROCOOL" GAS BURNER

4. (Of venturi type) assures low turndown without burnback

TYPE "S-A-D"

5. (Refuse Oil Burner) burns acids or caustic oils, sludges, asphalts, tank bottoms, polymer oils, heavy petrolatum, organic oil residuums, waste cutting oils, sulphite pulp liquors, etc.

NATIONAL **AIROIL** BURNER CO., INC.

Main Offices and Factory:
1239 E. SEDGLEY AVE., PHILADELPHIA 34, PA.
Southwestern Division: 2512 South Boulevard
Houston 6, Texas

• Keep Informed

potentiometer range in proportion to the voltage supplied to the strain gage bridge. The standardization (calibration) is maintained automatically at predetermined short time intervals by the well-known L & N standardization circuit. This means of maintaining calibration can also be actuated manually.

The circuit is adjusted by means of a two-position bridge supply switch (3 volts or 6 volts) and by a rheostat calibrated in gage resistance from 50 to 500 ohms. Microinch ranges of the recorder are 1000, 2000, 5000, and 10,000 on the 6-volt bridge and 2000, 4000, 10,000 and 20,000 on the 3-volt bridge. Continuous gage factor adjustment covers the range from 1.7 to 2.2. A zero adjustment control and range extender switch provide approximately plus or minus 15,000 microinches per inch movement of the balance point with 120-ohm gages.

Response to full scale unbalance is approximately 3 seconds. Response time for smaller unbalance is shorter. The instrument is ruggedly built and has a highly sensitive, precisely engineered circuit, the accuracy of which is unaffected by amplifier tube characteristics or changes, or by normal power supply voltage variations in all usual applications.

New Roller Chain Development Simplifies Assembly and Disassembly

Baldwin-Duckworth Div. of Chain Belt Co. announces a revolutionary development in roller chain construction known as the Baldwin-Rex "BA" Assembly. It is designed to simplify disassembly and assembly of roller chain in the field, on the job. It combines the advantages (longer life and lower cost) of riveted chain with the advantages (ease of disassembly and assembly) of cottered roller chain.

The new Baldwin "BA" Assembly consists of a 5-foot basic length of standard riveted roller chain with a revolutionary new single pin connector assembled at approximately the 2-foot mark and at the end of the basic 5-foot length. The connecting link employs one deteachable pin and one rivet. It is necessary to remove only one pin to disconnect the chain. There are no other loose parts, since the plates making up the connecting link all are securely press fitted to the remaining rivet. The new single pin connector has a distinctive tear-drop shape for easy identification.

A radically different pin make assembly and disassembly in the field amazingly easy. One end of the pin is spun over a washer, the other end has a milled flat and cotter pin. This pin is a slip fit throughout the chain with the exception of the milled flat end which is press-fitted into a special hole of the single pin connector plate. The other end of the single pin connector link has a riveted pin that is firmly riveted to the adjacent roller link. The "BA" Assembly is supplied in basic 5-foot lengths, packed two in a box. These basic units plus standard short units . . ."A" units, "B" unit, a 2-pitch unit, 6-pitch unit, and 10-pitch unit, plus offset links if desired . . . make it easy to build up the exact length of riveted roller chain desired without the need for cutting the riveted chain.

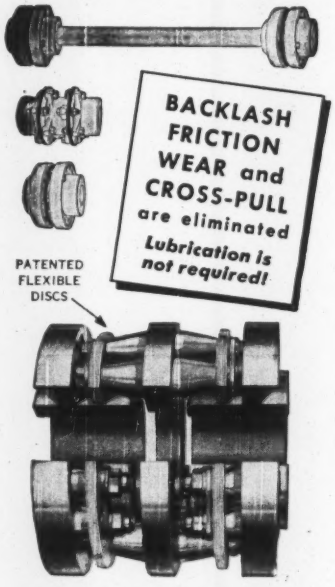
To disassemble the chain on the job, a single pin connector is readily located by its distinctive tear-drop shape and the special pin easily driven out. Since this special pin has a press fit on the milled flat end only, it is easy to remove. The press fit in one end, plus the washer on the other, assures a good, tight fit for longest pin and chain life. In addition, since it is necessary to remove or drive only one pin in or out and the other

THOMAS *Flexible* ALL METAL COUPLINGS
FOR POWER TRANSMISSION REQUIRE NO MAINTENANCE

Patented Flexible Disc Rings of special steel transmit the power and provide for misalignment and end float.

Thomas Couplings have a wide range of speeds, horsepower and shaft sizes:
½ to 40,000 HP
1 to 30,000 RPM

Specialists on Couplings for more than 30 years



THE THOMAS PRINCIPLE GUARANTEES PERFECT BALANCE UNDER ALL CONDITIONS OF MISALIGNMENT.

NO MAINTENANCE PROBLEMS.

ALL PARTS ARE SOLIDLY BOLTED TOGETHER.

Write for the latest reprint of our Engineering Catalog.

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA

• Keep Informed

pin in the link remains firmly riveted in, there is no chance for the plates to fall out when disassembling multiple width chains... you do not need to hold them in position when coupling the ends. And with the single pin connector, it is far easier to couple or uncouple the chain in cramped quarters. It requires less working space to replace a single pin connector link than a pin link and is easier to work on.

For ease in shortening chain that has become elongated through normal wear, it is recommended that an offset link be coupled to the single pin connector link at each 5-foot mark. This offset is easily removed since it is coupled to the single pin connector, the chain elongation taken up quickly and the chain back in operation in a remarkably short time. There is no need to replace links or wait for replacement links. The offset link uses the same type pin as the single pin connector link.

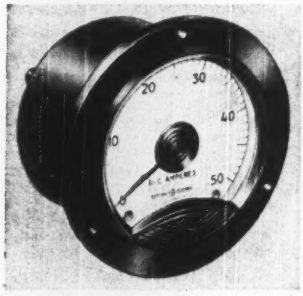
Where chains are subjected to unusual stresses and overloads are high, or where experience has shown early pin fatigue failures, Baldwin-Rex "BA" Riveted Assembly Roller Chain can be furnished with heat-treated pins. These carefully treated pins will assure far greater resistance to pin fatiuge failures.

The new "BA" Assembly is available for all standard roller chains from one inch pitch to larger sizes in both single and multiple.

For more information on the Baldwin-Rex "BA" Assembly, see your local Baldwin-Duckworth Roller chain distributor, or write Baldwin-Duckworth, Div. of Chain Belt Co., Springfield 2, Mass.

New Line of 3½-Inch, Long-Scale Panel Instruments Announced by General Electric

A complete new line of 3½-inch, long-scale panel instruments of internal-pivot-type construction has been announced by General Electric's Meter and Instrument Divisions.



Designated as Types DO-81 (direct current), DO-82 (thermocouple), and DO-83 (rectifier), the new instruments employ standard 3½-inch round and square cases with 250-degree scales 4.92 inches long for good readability.

Designed for general industrial applications, as well as for manufacturers of electronic devices, testing equipments, and similar apparatus, the instruments have permanent-magnet, moving-coil mechanisms. With the exception of high-sensitivity microammeters, they are available in all ratings now listed for conventional 3½-inch instruments with 90-degree scales.

The complete line, which falls into the 2 per cent basic accuracy class, is mechanically interchangeable with the 3½-inch round, wide-flange, and rectangular designs now

Continued on Page 58

Over 450 Aldrich-Groff Pumping Units—many with as much as nine years of service—are successfully operating today. And over 450 Aldrich customers have known and profited by a good investment. This service approaches that desired by Aldrich Pump designers and builders.

These many years successfully passed prove the endurance and low upkeep that are built into the Aldrich-Groff "POWR-SAVR"—a constant speed, controllable capacity pump. Its most obvious worth is usually associated with its stroke transforming action—supplying only that pressure actually needed. Less obvious is its long service economy.

For long service in the power field, for boiler or desuperheater feed, the Aldrich-Groff "POWR-SAVR" above, eliminates loss of power; and, as for mechanical reliability—there stands nine years proof of successful operation.

Send for material giving full details and ratings of Aldrich-Groff "POWR-SAVR" Controllable Capacity Pumps.

Representatives: Birmingham • Bolivar, N. Y. • Boston • Chicago • Cincinnati Cleveland • Denver • Detroit • Duluth • Houston • Jacksonville • Los Angeles New York • Omaha • Philadelphia • Pittsburgh • Portland, Ore. • Richmond, Va. St. Louis • San Francisco • Seattle • Spokane, Wash. • Syracuse • Tulsa

THE ALDRICH PUMP COMPANY

29 PINE STREET, ALLENTOWN, PENNSYLVANIA

The **FIRST** *Name in Reciprocating Pumps*

It's the Hi-Density Lead that makes

MICROTOMIC

"VAN DYKE"

your one best bet for tracings that "Come Clean" in reproduction!

Top that off with true UNIFORMITY OF GRADING and you have every reason for preferring MICROTOMICS, 18 degrees, from 9H to 7B.

TRADE MARKS REG U. S. PAT OFF

The EBERHARD FABER *Drawing Pencil*

AT BLUEPRINT & ENGINEERING SUPPLY HOUSES

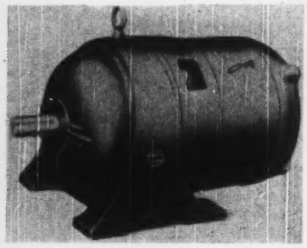
• Keep Informed

listed. The round design is interchangeable with conventional $3^1/_2$-inch round instruments which conform with Mounting Specifications JAN.-I-6.

Housed in molded Textolite cases which are dustproof and moisture resisting, the instruments are made for flush mounting on non-magnetic or steel panels. Because of the self-shielding characteristics of the concentric magnet, no special calibration is required for mounting on steel panels.

Foote Bros.-Louis Allis Announce New Line of Gearmotors

Foote Bros. Gear & Machine Corp. of Chicago and The Louis Allis Co. of Milwaukee have recently announced a joint program for the manufacture and sale of a complete line of gearmotors.



The new Foote Bros.—Louis Allis Gearmotor makes use of hard helical gears and other moving parts which have been processed and heat treated under new and improved methods of manufacturing control. These methods have produced new high standards of performance with regard to load carrying capacity, wear life, quietness of operation and compactness of design.

The new gearmotor, manufactured in 17 sizes, provides Single, Double and Triple reduction units having output speeds from 780 R.P.M. down to 7.5 R.P.M. Integral horsepower ratings from 1 through 75 horsepower are available for practically any industrial application.

A wide selection of motor enclosures is offered, including the conventional open drip-proof, splash-proof, totally enclosed and explosion-proof construction. A.C. and D.C. motors of all types, as well as motors having special electrical characteristics, are available to meet unusual installation and application requirements.

Information on the Foote Bros.-Louis Allis Gearmotor is obtainable from either company.

• BUSINESS CHANGES

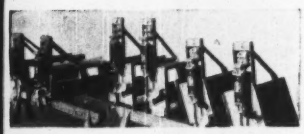
Davis Regulator Co. Celebrates 75th Anniversary

As America's pioneer manufacturer of steam pressure reducing valves, Davis Regulator Co. of Chicago this year is celebrating its seventy-fifth anniversary. Headed by George C. Davis, President, who has been in the business for more than fifty years, the organization has aided and participated in virtually the entire period of this country's great industrial development.

The company was founded in 1875 by Mr. Davis' father, George M. Davis, and for many years the firm was known, first, as G. M. Davis & Co., and later as The G. M. Davis Regulator Co. The senior Mr. Davis' interest in the design and use of valves stemmed from early experience in the then in-

Ledeen heavy duty cylinders helped do this job *better*

FLOW CONTROL OF POWDERED PLASTIC TO MOLDS AND PRESSES



APPLICATION—Finely powdered plastic chemical is stored in bins; must be fed accurately to molds and presses. Bin valves at the bottom of each hopper are operated by 4" diam. x 8" stroke Ledeen cylinders. The resulting control of material flow is both accurate and fast.

OPERATION—The cylinders are air operated, and all valves are remote controlled. Each cylinder is suspended vertically from the frame by its upper cylinder head; attached to the bin valve crank by a clevis on the piston rod. Vertical adjustment is provided to assure accurate opening and closing.

Perhaps you too have a job that can be improved by Ledeen heavy duty cylinders.

Wherever you have to...

PUSH OR PULL, LIFT OR LOWER, PRESS OR SQUEEZE, TILT OR TURN, OPEN OR CLOSE,

Ledeen heavy duty cylinders, operated by air, oil or water, will do it for you better and surer.

Standard Ledeen Cylinders with rod or head attachments are available from distributors' stock in major cities. Special cylinders on order.

Write for Bulletin 453.

Ledeen Mfg. Co.

DIV OF ENGINEERING PRODUCTS CO
1600 SAN PEDRO • LOS ANGELES 15, CAL

LEDEEN CYLINDERS ARE GOOD CYLINDERS • LEDEEN CYLINDERS ARE GOOD CYLINDERS • LEDEEN CYLINDERS ARE GOOD CYLINDERS

• Keep Informed

fant steam heating industry where he worked on the manufacture of air vents for radiators. Sometime in the year 1874, he conceived the idea of improving and manufacturing an automatic steam pressure reducing valve of a type occasionally used and manufactured at that time in Germany. Starting with what was then a crude and unreliable mechanism in his small shop located at 22 S. Canal St. in Chicago, he redesigned, simplified, and improved the valve until it became the Davis Pressure Reducing Valve. It is of interest to note that this design is still embodied in one of the basic types of pressure regulators which the company manufactures today.

This development came in response to repeated demands from the steam engineers of the day for a means of using steam at lower pressure (and temperature) than that provided by the boiler direct. Thus, this new pressure regulator soon became the key to maintenance of comparatively low, controlled temperatures for steam heating, cooking kettles, beer vats, candy drums, and many other applications where it was found to be more economical to use low, uniform pressures.

From the start, the Davis venture had many helpful friends. Such pioneers as Richard T. Crane of what is now known as The Crane Co., L. H. Prentice of the old established firm of Hay & Prentice, John Davis of the John Davis Co., and Sam Pope of Pope & Co. all helped to encourage the use of Davis reducing valves.

Contact with the developing industrial field led to the design of numerous other pressure, flow, and control devices. The senior Mr. Davis invented several automatic pressure reducing valves and steam traps and the sale of these new devices at that time was a matter of personal introduction and sales effort. For many years, however, the Davis Pressure Reducing Valve was the pioneer of its kind. In 1885 the Davis Automatic Noiseless Semi-Balanced Type Back Pressure Valve was invented. The Davis Combined Pump Governor and Reducing Valve was another power plant accessory added to the line in 1888.

Over the years, the business enjoyed steady growth and was moved from the Canal Street address in Chicago to larger quarters, first at 100 North Clinton St. in 1885, then to 422 Milwaukee Avenue in 1900, and finally to the present address at 2541 South Washtenaw Avenue in 1930. Throughout its history, the Davis Company has had the benefit of being staffed by personnel with long experience in the business. The founder, George M. Davis, remained active for 35 years. Of its present executives, Charles A. Swanson, Shop Superintendent, started in 1905, George V. Hochmeister, Chief Engineer, in 1918, and H. R. Willard, Chicago District Sales Representative, in 1924. R. A. Peterson, who died November 20, 1949, while serving as Sales and Advertising Manager, had been with the company since 1922. Besides George C. Davis, President and Treasurer, the present directors of the company are H. A. Davis, and W. D. Dunning, Secretary.

One of the last projects completed by Mr. Peterson before his death was the preparation of a Diamond Jubilee edition of the Davis general catalog. This is now being distributed to many customers and copies are available to interested readers on request.

Under the leadership of George C. Davis, the company, in recent times, has been active in the development of many types of solenoid operated control valves and liquid

Continued on Page 60.

ACTUAL CHECK PROVES

No other Copying Process offers you the ECONOMY *of* OZALID!

HERE'S PROOF!

Check the money-saving versatility of Ozalid against the four other most popular copying methods—compare yourself, point for point:

	OZALID	METHOD A	METHOD B	METHOD C	METHOD D
Prints ready for immediate use	✓	✓	✓	✓	✓
No size restrictions	✓			✓	
No special plates, stencils, or inks	✓	✓	✓		✓
No need to make negative	✓				
Additional copies immediately available	✓				
Easily makes duplicate masters	✓				

WHAT IS OZALID?

• Ozalid is a *speedy copying process* that uses sensitized paper to reproduce anything typed, drawn or written. You get perfect copies of letters, records, reports, photographs, index files, drawings—anything.*

WHAT ARE THE ADVANTAGES OF THE OZALID PROCESS?

• **No size restrictions**—Ozalid copies can be made in *any* size, in sheets or continuous rolls.

• Copying errors are eliminated. There's no *check-back* to the original.

• Changes easily made. Add new material to create a "composite master". No need to re-create an entire piece.

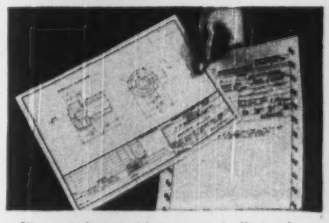
OZALID PAPER IS UNEQUALLED FOR QUALITY, TOO!

• For years, Ozalid has been established as the "Standard of Quality" among sensitized papers.

• Ozalid's "speed" is the same, month in and month out—stepping up production.

• Controlled product quality gives more prints at lower labor cost.

• Longer shelf-life—means less waste.



You get dry, positive, exact duplicates in a fraction of a minute and at a fraction of your usual cost.

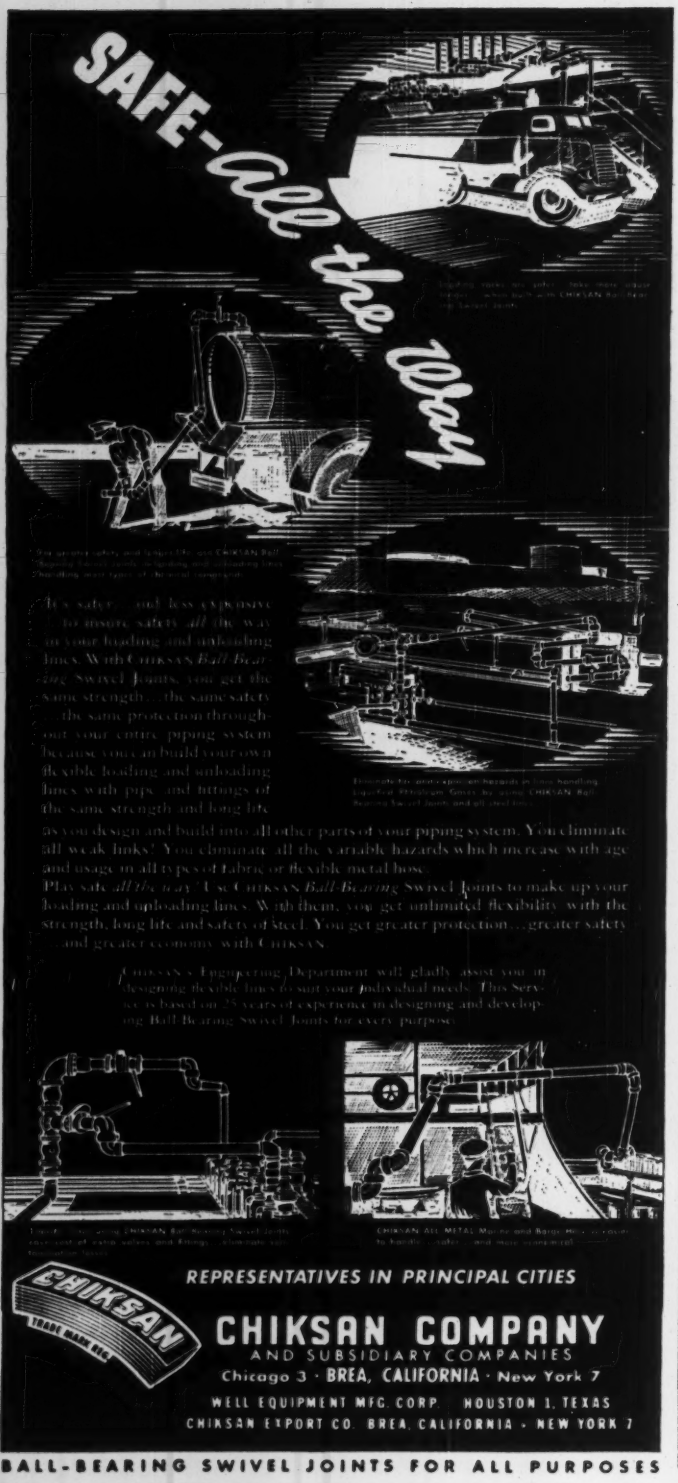
**If light won't shine through, an inexpensive intermediary step is taken.*

OZALID, Dept. K1
Johnson City, New York
Gentlemen: Please send free illustrated booklet that fully explains the Ozalid process.

Name .....
Company .....
Address .....

Cut Copying Costs...Use OZALID!

A DIVISION OF GENERAL ANILINE & FILM CORPORATION. "FROM RESEARCH TO REALITY"


SAFE-all the way
It's safer—and less expensive to insure safety all the way in your loading and unloading lines. With CHIKSAN Ball-Bearing Swivel Joints, you get the same strength... the same safety... the same protection throughout your entire piping system because you can build your own flexible loading and unloading lines with pipe and fittings of the same strength and long life as you design and build into all other parts of your piping system. You eliminate all weak links! You eliminate all the variable hazards which increase with age and usage in all types of fabric or flexible metal hose.
Play safe all the way. Use CHIKSAN Ball-Bearing Swivel Joints to make up your loading and unloading lines. With them, you get unlimited flexibility with the strength, long life and safety of steel. You get greater protection... greater safety and greater economy with CHIKSAN.
CHIKSAN Engineering Department will gladly assist you in designing flexible lines to suit your individual needs. This Service is based on 25 years of experience in designing and developing Ball-Bearing Swivel Joints for every purpose.
CHIKSAN
TRADE MARK REG.
REPRESENTATIVES IN PRINCIPAL CITIES
CHIKSAN COMPANY
AND SUBSIDIARY COMPANIES
Chicago 3 · BREA, CALIFORNIA · New York 7
WELL EQUIPMENT MFG. CORP. HOUSTON 1, TEXAS
CHIKSAN EXPORT CO. BREA, CALIFORNIA · NEW YORK 7
BALL-BEARING SWIVEL JOINTS FOR ALL PURPOSES

• Keep Informed

level control devices. Mr. Davis has patented a number of automatic valves for the petroleum and natural gas industry and is recognized as an authority in this field.

Throughout the company's history, it has had a hand in leading engineering and technical developments. Giant strainers of Davis manufacture are to be found in great hydroelectric power and flood control dams. Famous power plants have large Davis relief valves protecting turbines and condensers. During World War II, Davis supplied valves for uses ranging from submarines to atomic energy plants. In general industry, there are few plants in which at least one of the fifty-five type of Davis products will not be found.

• LATEST CATALOGS

Steam Boilers for Processing and Heating

The Cleaver-Brooks Co. of Milwaukee, builders of equipment for the generation and utilization of heat, has announced the publication of a new catalog designed to point out the advantages of self-contained, oil and gas fired steam boilers for processing and heating.

The attractive, 12-page, four-color catalog is available to all users of steam boilers. Illustrated are various sizes of steam boilers, ranging from a 15 to 500 H. P. and 15 to 200 P.S.I.

Included in the catalog is a diagrammatic cross-section illustration representative of the Four Pass design found in Cleaver-Brooks boilers.

Stressed throughout are the advantages gained in installing a Cleaver-Brooks steam plant. Oil fired, gas fired and combination oil and gas fired boilers are shown.

The catalog can be obtained by writing on your business letterhead to Cleaver-Brooks Co., 326A East Keefe Ave., Milwaukee, Wis.

Low Cost Plastic Caps for Alemite Fittings

S. S. White Elastoplastic Caps are designed to fit over $\frac{3}{8}$" Alemite Dot Fittings to prevent dirt and other matter from lodging on the tip. This protection is particularly important for chemical, cement, foundry and similar machinery which are run under dirty or dusty operating conditions, since abrasive matter can easily be forced into the fitting on the first lead-in shot of the grease gun and result in scored bearings.

Elastoplastic Caps are made of black, flexible vinylite. They are easily applied and removed, and hold by friction fit. They are not affected by oils, grease or gasoline.

Full information and prices can be obtained from the S. S. White Dental Manufacturing Co., Plastics Division, 10 East 40th Street, New York, 16, N. Y.

Gifford-Wood Announces New Bulletin

Gifford-Wood Co., Hudson, N. Y., announces publication of a new bulletin describing 14 case histories of coal handling and storage systems.

These installations were all based upon the use of any one of Gifford-Wood's four basic types of storage and handling systems which feature simplified design, engineering, erection, and low initial and ultimate cost. These basic types are an outgrowth of 135 years of experience in applying hundreds of engineered designs for coal storage and handling equipment. The bulletin explains how they may be economically adapted to suit varying conditions of space, capacity, climate and allowable initial cost. It also shows how

• Keep Informed

these basic designs were specifically selected for various types and capacity of storage and how preparation and handling systems were designed around them.

Steam generating plant operators, owners and consulting engineers should find the large cross section drawings valuable. They contain complete nomenclature which designates the essential engineering data on each of the 14 installations.

A copy may be had upon request by writing Gifford-Wood Co., for Bulletin No. 300.

Continuous Tooth Herringbone Gear Speed Reducers

A new 48-page catalog #40-B covering continuous tooth herringbone gear reduction gears. The ratio range from 2 to 360 to 1 with capacities up to 3500 H.P. This book contains rating tables with simplified methods of selection, of proper drive.

Horse power ratings, overhung load capacities, dimensions and weights of single, double and triple reductions.

Improved accuracy or the generated continuous tooth gear with higher quality or materials, improved methods of heat treatment with close manufacturing tolerances. These continuous tooth herringbone gear reductions are available in 65 sizes. Send for catalog 40-B. D. O. James Gear Mfg. Co., 1140 West Monroe St., Chicago 7, Ill.

Union Steam Generators

Union Iron Works, Erie, Pa., has available latest Bulletins describing their Type "S" Steam Generators which are self-contained units designed for boiler rooms limited in width and headroom. These boilers have ample water cooled furnace volume for single retort underfeed, spreader stoker, oil or gas firing. Complete data is given for the 8 standard sizes from 1000 to 4000 sq. feet of boiler heating surface. Write for Bulletin 119.

Unusual Application of Roller Chain

The Baldwin-Duckworth Div., of Chain Belt Co. has just published bulletin #49-2, "Unusual Applications of Roller Chains" which will be of value to all machinery and drive designers.

The material for this 24-page bulletin, assembled with the help and cooperation of designers throughout the country, suggests the broad application of roller chain by means of a representative showing of very unusual applications.

Each application is described, illustrated with photos and, in the case of complicated machinery, with simplified working drawings. This bulletin is available for all interested engineers. To get a copy, write Chain Belt Co.; 1600 West Bruce Steet; Milwaukee 4, Wis. and ask for bulletin #49-2, "Unusual Applications of Roller Chain."

Soft Bunker Oil Market Accents Delayed Coking

Softening of the market for heavier grades of fuel oil has brought new economic significance to the refining process known as Delayed Coking, according to "Kelloggram" No. 5 (1949), just published by The M. W. Kellogg Co., refinery and chemical engineers of Jersey City, N. J.

Not only does this present evaluation take into consideration the fact that the process produces high grade coke instead of fuel oil as a residual product, but it also recognizes the flexibility of the unit, which can also be used for Visbreaking when heavy fuel oil is again desired as a by-product.

However, the "Kelloggram" points out, the production of coke is merely a step for obtaining a more marketable by-product and

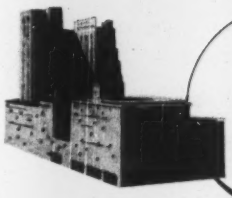
Continued on Page 82

SPENDS $82,000 SAVES $94,718

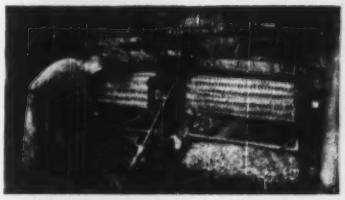
the first year

WITH

PEABODY OIL BURNERS



The Hotel St. George in Brooklyn *saved the cost of the entire installation* **in less than one year by converting from coal to Peabody Oil Burners.**

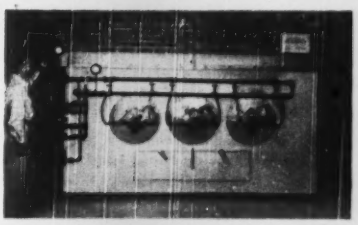


Before . . .

The St. George Hotel used 17,000 tons of bituminous coal a year to fire four 400-HP boilers operated at 75% efficiency. Conversion to oil was based on records dating back to 1928 and included *all* costs of operation.

After

Dirt and dust, along with coal bins and stokers, ash removal problems and maintenance expense, together with high labor costs, have been eliminated by Peabody oil burning equipment that fires these same boilers at 81% efficiency!



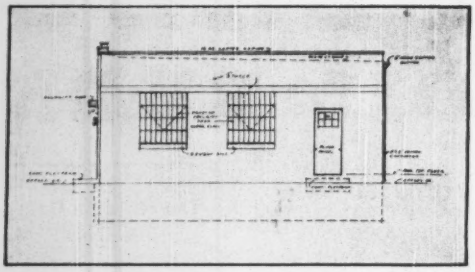
PEABODY PRODUCTS INCLUDE: *Automatic Gas and Oil Burners • Pump and Heater Sets • Direct Fired Air Heaters • Gas Scrubbers, Coolers and Absorbers • Burners, singly or in combination, for firing Oil, Pulverized Fuel, and Gas (manufactured, natural, refinery or blast furnace).*

509

OFFICES IN PRINCIPAL CITIES

PEABODY ENGINEERING CORPORATION
580 FIFTH AVENUE • NEW YORK 19, N. Y.
Manufacturers of all types of combustion equipment, direct fired air heaters, gas scrubbers, coolers and absorbers

with CONCRETE
— the small extra first cost of test samples pays off in assurance of efficiency and durability of the finished structure.



with TRACING CLOTH . . .

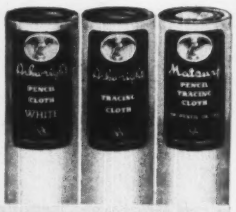
The small extra first cost of Arkwright Tracing Cloth, over that of tracing paper, repays many times over in the efficiency and durability of valuable drawings.

Arkwright gives both immediate *and* future advantages. The expert work of the draftsman is made permanent. Your investment in time and money is backed by sharp, clean reproductive quality. Under repeated use — or on file for subsequent need — Arkwright assures perfect drawing performance year after year.

For every drawing worth keeping for future use — use permanent Arkwright instead of perishable tracing paper. Send now for generous samples and prove this superiority. Sold by leading drawing material dealers everywhere. Arkwright Finishing Company, Providence, R. I.

The Big Six Reasons Why Arkwright Tracing Cloths Excel

1. Erasures re-ink without feathering.
2. Prints are always sharp and clean.
3. Tracings never discolor or go brittle.
4. No surface oils, soaps or waxes to dry out.
5. No pinholes or thick threads.
6. Mechanical processing creates permanent transparency.



ARKWRIGHT
TRACING CLOTHS
AMERICA'S STANDARD FOR OVER 25 YEARS

• Keep Informed

is not the basic objective of Delayed Coking. Essentially, the process is employed as a means of producing maximum yields of extra-clean feed stocks for catalytic cracking from any type of reduced crude.

Underlining the importance of the design of furnaces to the efficient operation of Delayed Coking units, the "Kelloggram" states that through careful designs Kellogg units have been kept continuously on stream for periods from six to eight months. Recent inspections of furnace tubes at the end of these extended runs have indicated that appreciably longer runs are possible, which will further improve the economics of the process.

In addition to covering some of the economic aspects of Delayed Coking, this issue also discusses the process itself and some of its possible variations.

Chiksan Ball-Bearing Swivel Joints

Chiksan Catalog No. 50, issued by Chiksan Co., Brea, Calif., illustrates and describes over 500 different types and sizes of Chiksan Ball-Bearing Swivel Joints. There are seven basic types for temperatures and pressures from −25° F. to 600° F. and from vacuum to 15,000 psi. Sizes range from $^3/_8$" to 12". In addition, Catalog No. 50 carries a complete description of Chiksan All-Steel Rotary Hose, All-Metal Marine and Barge Hose, All-Steel Cementing and Circulating Hose, Circulating Heads and Mud Guns. Copies are available on request.

This composite catalog also contains the Unions, Blocks and Thread Compounds manufactured by the Well Equipment Mfg. Corp., subsidiary of Chiksan Co., as well as the Low Pressure Gas Burners and Warehouse and Derrick Stoves manufactured by Anchor Burner Company and distributed by Chiksan representatives outside the Greater Mid-Continent area.

New Link-Belt Book for Grain and Allied Processing Industries

A 20-page Book No. 2305 has been published by Link-Belt Co., illustrating and briefly describing the materials handling and power transmission equipment that the company most commonly supplies to the grain and allied processing industries for efficient, low-cost operation.

This equipment includes box car unloaders, power unloading scoops, electric car spotters, screw conveyors, bucket elevators, Bulk-Flo conveyors, belt conveyors, oscillating conveyors, vibrating screens, bean flake dryers-coolers, "HS" high-speed elevator buckets, conveyor idlers, welded steel pulleys, chain drives, Electrofluid drives, Gearmotors, variable speed drives, automatic backstops, bearings, take-ups, clutches, couplings, etc.

A copy of this new Book No. 2305 will be forwarded to any interested reader upon receipt of request, which may be addressed to the nearest Link-Belt office.

Rex Sprockets

Chain Belt Co. of Milwaukee has just published bulletin #49-30 describing and listing with prices Rex Stock Size Cast Sprockets for the complete line of Rex Drive and Conveyor Chains.

Dimensions, specifications, list prices, sprocket style and all other necessary information are included in this bulletin. Sprockets for virtually all sizes and styles of chain with the exception of chain using cut tooth sprockets are completely listed.

In addition to the above data, rules for selection, alignment and care of sprockets are given together with complete information on

• Keep Informed

what should be included when ordering sprockets.

For a copy of this Rex Stock Size Cast Sprocket bulletin, write Chain Belt Co., 1600 West Bruce Street; Milwaukee 4, Wisconsin and ask for bulletin #49-30.

New Profilometer Bulletin Covers Operating Features

An illustrated bulletin describing the advantages of the Profilometer for shop measurement of surface roughness is announced by Physicists Research Co.

Entitled "Practical Operating Features of the Profilometer," this new publication covers the instrument's suitability for use in production departments, simplicity and speed of operation, dependability of roughness readings, and broad versatility. Illustrations show the range of work measured, including small holes, internal grooves, deep bores, circular surfaces, and other surfaces whose roughness cannot be measured by any other means.

In addition, the bulletin tells why an extensive line of equipment is needed to provide for measuring the roughness of all surfaces produced by sizing and finishing operations; and typical items from the Profilometer line are shown in use.

Copies of this bulletin are available on request from Physicists Research Co., 321 S. Main St., Ann Arbor, Mich.

Strain Gages for Stress Analysis

SR-4® Gages for Stress Analysis. Baldwin Locomotive Works, Philadelphia 42, Pa., announces a new 12-page bulletin, No. 279-A, which tells how to select and use SR-4 bonded resistance wire strain gages in stress analysis. It explains the fundamentals of both simple and practical strain gage circuits and instruments, illustrating eight circuits and eight different types of instruments.

Instruments range from a Wheatstone bridge control box to oscillographic equipment and automatic self-balancing indicators and recorders, and include switching units for multiple gage installations. A section on "Calculation of Gage Output" gives derivations of formulas for computing simple dynamic circuits and Wheatstone bridge circuits, and includes examples of these computations.

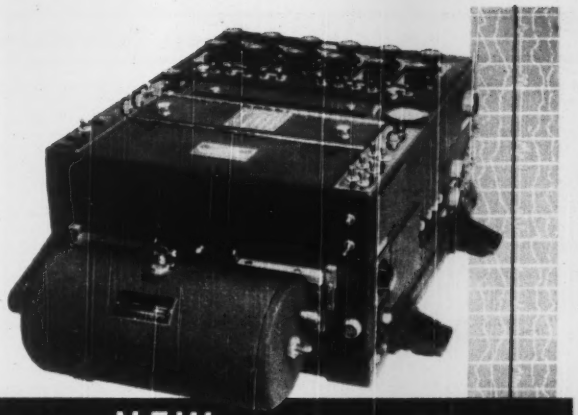
Rotary Positive Gas Pumps

Roots-Connersville Blower Corp. of Connersville, Ind., has just issued Bulletin 31-B-17, covering its Type XA Gas Pumps, which are used as boosters or exhausters in a wide range of industrial and other applications according to the manufacturer. These units are built in 18 standard sizes with capacities ranging from 5 to 620 CFM at pressures up to 2 lbs., from 5 to 320 CFM up to 4 lbs., and from 5 to 175 CFM up to 6 lbs., thus offering an extremely wide selection from stock.

Printed in two colors, this 8-page booklet discusses the advantages of the rotary positive principle, which had its inception with the Roots brothers, about 1854. Sectional views are included, along with a chart to graphically illustrate volume and power characteristics of constant pressure and variable-speed, multi-speed, or constant-speed drives. Numerous illustrations appear to show the variety of drives.

These R-C gas pumps have been widely adapted by manufactureres of processing equipment in the chemical industry, and several cuts are shown to illustrate such integral mountings of the units. They also find application in combustion processes, for removing by-product gases and vapors, in the distribution of both natural and manufac-

Continued on Page 64



the *NEW* S-8 Oscillograph

Here, in a versatile instrument of advanced design, are all the things you need for complete oscillographic recording. The Hathaway Type S-8 Oscillograph, which has long been the standard of oscillographic recording, has been improved to meet the rapidly expanding demands of modern research. Whether your measurement problems are simple or complex, the NEW Type S-8 Oscillograph has the inherent capabilities necessary to measure vibration, pressure, acceleration, and strain with new ease and accuracy.

The newest features include:

QUICK-CHANGE TRANSMISSION *fully enclosed with gears running in oil* **to provide instantaneous selection of 16 record speeds over the range of 120:1**

CHART TRAVEL INDICATOR *provides continuous indication of chart motion. Operator knows instantly by flashing lamp if anything should happen to interfere with chart motion*

FULL-RESILIENT MOUNTING FOR MOTOR AND TRANSMISSION *isolates all possible vibration and makes possible the use of modern super-sensitive galvanometers*

NEW GALVANOMETER STAGE *accommodates all Hathaway galvanometer for recording milliamperes, microamperes, or watts*

NEW RECORD-LENGTH CONTROL AND NUMBERING SYSTEM *designed for long, trouble-free service under all kinds of ambient conditions*

All the other valuable features are retained, such as

PRECISION TUNING-FORK-CONTROLLED TIMING SYSTEM *produces either 1/10-second or 1/100-second time lines across sheet*

WIDE RANGE OF GALVANOMETER TYPES AND CHARACTERISTICS *provide for almost any recording requirements. Natural frequencies to 10,000 cps. Sensitivities to 50,000 mm per ma, single and polyphase watts*

DAYLIGHT LOADING AND UNLOADING RECORDS TO 200 FT. IN LENGTH, width to 10 inches

SIMULTANEOUS VIEWING AND RECORDING

AUTOMATIC BRILLIANCY CONTROL

12 TO 92 ELEMENTS

Whatever your needs may be, investigate the NEW Type S-8 Oscillograph and its 170 types of galvanometers — the most versatile equipment in existence for general-purpose applications.

WRITE FOR BULLETIN 2B-1K

Hathaway
INSTRUMENT COMPANY
1315 SO. CLARKSON STREET • DENVER 10, COLORADO

tured gas, for boosting low-pressure natural gas wells, etc. These pumps handle hydrogen, oxygen, CO_2, and many other gases. Several installations are shown.

A rating table is carried covering the low, medium, and high pressure ranges, along with a dimension sheet covering all sizes. On the back cover, "R-C dual-ability" is briefly described, as Roots-Connersville claims to be the only maker of both rotary positive and centrifugals.

How to Apply SR-4 Strain Gages

How to apply SR-4® Strain Gages, Bulletin No. 279-B, is announced by The Baldwin Locomotive Works, Philadelphia 42, Pa. This 8-page bulletin gives detailed procedures for attaching SR-4 resistance wire strain gages to surfaces and is illustrated by 18 cartoons animating the strain gages to show their reactions to correct and incorrect methods.

Instructions are given for surface preparation, cementing, clamping, heat drying, moisture-proofing, and testing of gages after bonding in order to assure proper application. These instructions include the variations of methods developed for four general classes of gages and to alternate methods of application.

Contour Projector

A new, eight-page booklet describing the Kodak Contour Projector provides information on rapid optical inspection of parts by comparing the enlarged image of the part with a tolerance chart.

Conventional shadow projection is illustrated, together with surface projection for inspecting blind holes and other dimensions that cannot be silhouetted. The use of special fixtures is briefly discussed and numerous pictures and schematic drawings illustrate how the Kodak Contour Projector may be used for a wide variety of inspection problems.

The booklet is available without charge from the Industrial Optical Div., Eastman Kodak Co., Rochester 4, N. Y.

New Ball Bearing Catalog

A new Catalog No. 140, announced by the Nice Ball Bearing Co., Philadelphia, Pa., describes and illustrates a complete line of ball bearings and introduces a new composition sealed bearing design. The line covers radial, thrust and combined radial-thrust bearings ranging from close tolerance precision units to inexpensive pressed steel bearings of the unground type.

Listings cover other Nice anti-friction products such as ball bearing sheaves, rollers, wheels and casters. Listings also include capacity ratings and complete list price and discount information.

Heavy Duty Counters

The Richardson Scale Co., of Clifton, N. J. offers a six-page folder which describes and illustrates its complete line of heavy duty counters. They were designed primarily for manufacturers and users of equipment where dependable, accurate counting and recording of unit production is vital.

Twenty models are listed — standard tripped types, motor driven types, ticket printing types, automatic stopping counters and explosion proof units. Developed over a period of 30 years as an accessory of Richardson Automatic Scales, each model is extra rugged and precision built, for unvarying accuracy and to provide positive protection against the hazards of dust, moisture, corrosion and explosion.

In order to eliminate clerical errors due to slips of memory or illegible handwriting and to facilitate bookkeeping records... Richardson ticket-printing counters issue a printed record with duplicate carbon copy. This counter has been used for more than thirty years in grain shipping commerce.

Write manufacturer for copies of Bulletin No. 3149.

Heavy Duty Compressors

Pennsylvania Pump & Compressor Co., Easton, Pa., announce a new 24-page bulletin describing Pennsylvania Duplex Compressors. The air or gas compressors described are of the horizontal, duplex, double acting, water-cooled type, for either single- or two-stage compression. Standard sizes are available in capacities up to 2270 cubic feet piston displacement for pressures of 80 to 125 p.s.i. gauge. One interesting feature of this bulletin is the very complete coverage given to the Pennsylvania Air Cushion Valve on page 8 and 9.

Union Offers New Catalog

Union Iron Works, Erie, Pa., describes its line of all-welded Little Giant 150 w.s.p. Boilers in a new catalog. These standardized boiler units include pressure element, steel casing and refractory lined furnace. Their installation requires only a small base, stack and piping connections. Complete construction details are given and specifications cover 10 sizes from 15 thru 80 Horsepower. They are designed for all firing methods. Write for Bulletin No. 120.

Vibration Fatigue Testing for Every Industrial Need

No matter what the size of your laboratory . . . whether the devices to be tested weigh a few ounces or a hundred pounds . . . or whether vertical or horizontal vibration is involved . . . there's an All American Vibration Fatigue Testing Machine that will tell you quickly and accurately how your product will stand up in service.

8 models, producing vibration vertically or horizontally; frequencies of 600 to 3,600 v.p.m. Quick delivery!

Send for Catalog F.

Model 10VA. Load capacity 10 lbs. Produces vibration vertically.

Model 25HA. Load capacity 25 lbs. Produces vibration horizontally.

Model 100VA. Load capacity 100 lbs. Produces vibration vertically.

Made by makers of ALL AMERICAN ILLUMINATED LAYOUT PLATE WITH 16X MICROSCOPE

ALL AMERICAN
Tool & Manufacturing Co.
1016 W. FULLERTON AVE. CHICAGO 14, ILL.

When your concrete floors develop cracks, ruts, shallow holes or rough spots, repair them with Smooth-On No. 7B Quick Floor Patch Cement. It comes in powder form ready to mix with water. Simply apply Smooth-On No. 7B as you would plaster. Smooth-On No. 7B expands slightly as it hardens, insuring a secure, tight fit. You get an iron-hard surface that can take the punishment of heavy traffic. Order Smooth-On No. 7B Quick Floor Patch Cement in 1, 5, 20, or 100 lb. size.

FREE *Folder and Repair Handbook*

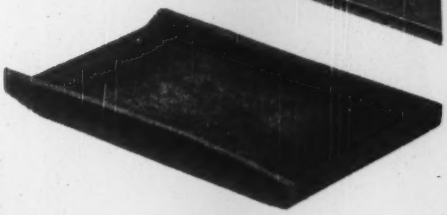
Write for your copy of the illustrated Smooth-On Quick Patch folder and the famous Smooth-On Repair Handbook. Pocket size, 40 pages, 170 simple illustrations. Shows how to make many time-saving, money-saving repairs.

SMOOTH-ON MFG. CO., Dept. 56
570 Communipaw Ave., Jersey City 4, N. J.
SO-349

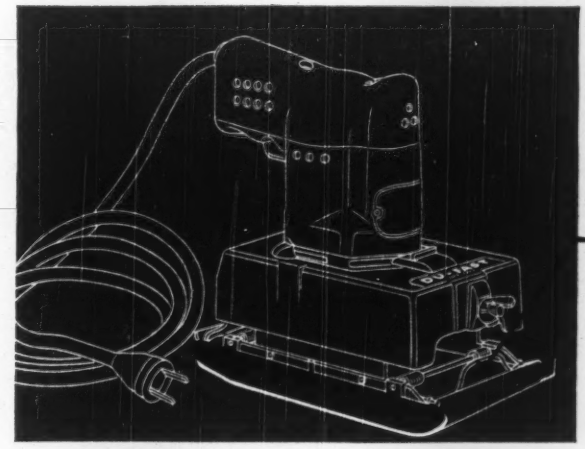
Do it with **SMOOTH-ON**
QUICK FLOOR PATCH CEMENT

to an imaginative product designer . . .

Spongex® resilience



yielded this idea



to become

this product feature

Du-Fast sander and polisher attachment for home utility ¼" electric drill. Attachment only by Du-Fast, Inc., N. Y.

• Cellular rubber does not become a "product" until you make it one in *your* application of its known qualities as insulation against shock, vibration, sound and air and temperature transmission.

Du-Fast, Inc., wanted a sander/polisher block sufficiently resilient for conformation to curved and irregular surfaces, yet firm enough for efficient sanding and polishing. Du-Fast got the resiliency they wanted in the illustrated *Spongex* form compounded for the desired density and compression range and molded to the specifications of the unit it serves.

In every industry there exists problems that *Spongex* cellular rubber may solve. Think about it. If your thoughts are on vibration, insulation, cushioning, gasketing, sealing or sound damping, we can be your greatest help.

THE SPONGE RUBBER PRODUCTS COMPANY

301 Derby Place, Shelton, Conn.

Looking for a Possible Variation in the "Fluff"

Precision in the making of corrugated shipping containers is as essential as in the manufacture of the thousands of products these containers carry safely to their destinations. In the mills of The Ohio Boxboard Company at Rittman, Ohio, the Strobotac checks several manufacturing operations, not the least of which is shown above. Here are the how and the why in their own words:

> "The beam was focused on the single facer where the corrugated medium (.009" straw) left the flute roll and "fluffed" out on the fingers before the adhesive is applied. The "fluff" must be uniform to achieve uniform adhesion, otherwise blisters will form. Even though we had to use a double image, due to the frequency being about 360 per minute, we were able to spot faulty finger adjustment which resulted in blistered board. By use of the Strobotac we were able to correct faulty adjustment very quickly."

Here, as in hundreds of instances, the Strobotac flash, by "stopping motion," reveals conditions and causes, effects and defects, previously hidden or obscured.

TYPE 631-B

STROBOTAC

Direct-Reading Flashing Speed Range: from 600 to 14,400 per minute — stops motion from 100 to 100,000 rpm.

Flash Duration: between 5 and 10 microseconds.

Power Supply: 115 volts, 60 cycles.

Power Input: 25 watts.

Dimensions: 7½ x 8¼ x 9⅞ inches.

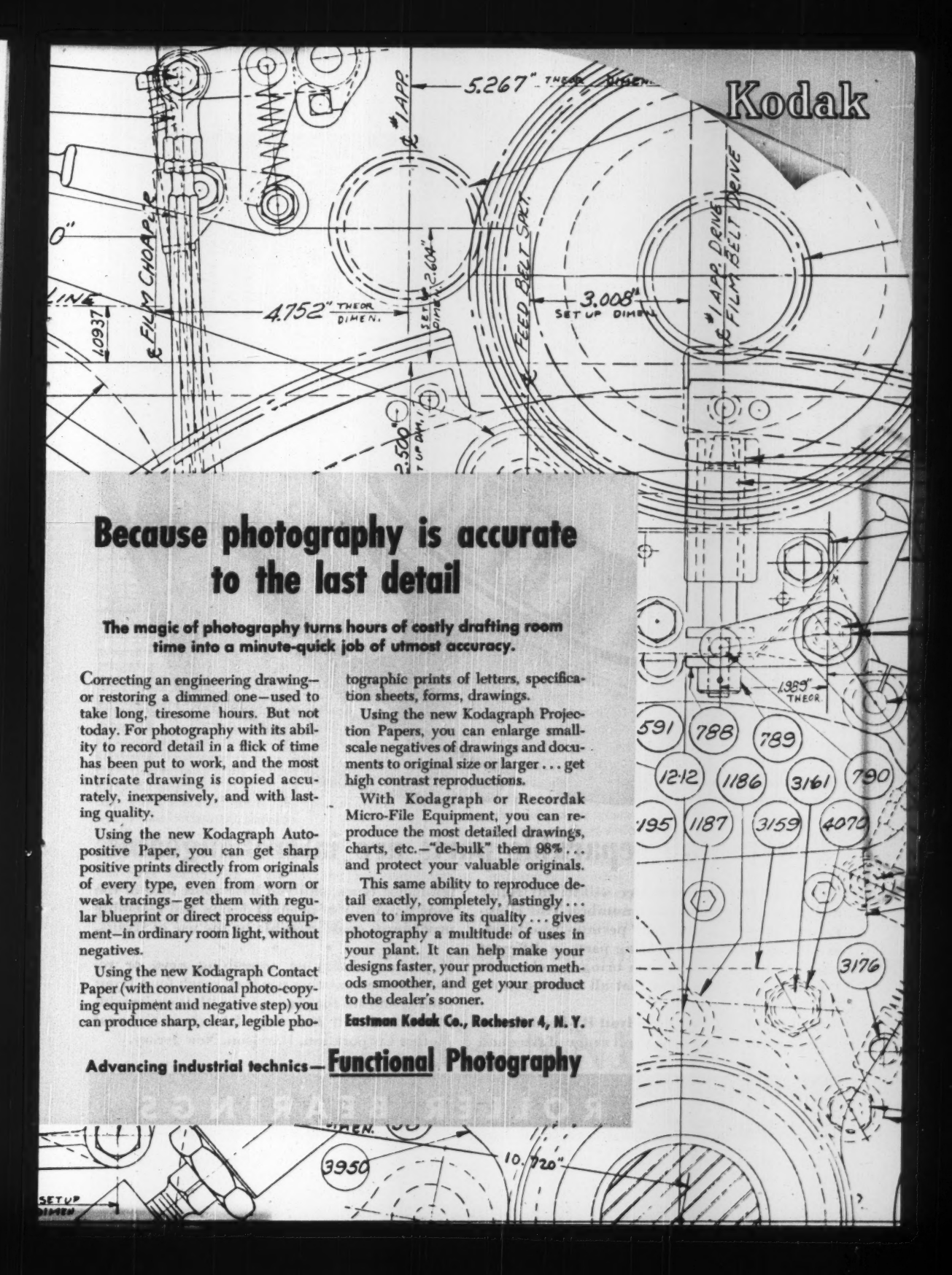
Price: $125.00

Write for your 24 page manual of stroboscopic techniques, "Eyes for Industry."

GENERAL RADIO COMPANY

Cambridge 39, Massachusetts

90 West St., New York 6 — 920 S. Michigan Ave., Chicago 5 — 1000 N. Seward St., Los Angeles 38



Because photography is accurate to the last detail

The magic of photography turns hours of costly drafting room time into a minute-quick job of utmost accuracy.

Correcting an engineering drawing—or restoring a dimmed one—used to take long, tiresome hours. But not today. For photography with its ability to record detail in a flick of time has been put to work, and the most intricate drawing is copied accurately, inexpensively, and with lasting quality.

Using the new Kodagraph Autopositive Paper, you can get sharp positive prints directly from originals of every type, even from worn or weak tracings—get them with regular blueprint or direct process equipment—in ordinary room light, without negatives.

Using the new Kodagraph Contact Paper (with conventional photo-copying equipment and negative step) you can produce sharp, clear, legible photographic prints of letters, specification sheets, forms, drawings.

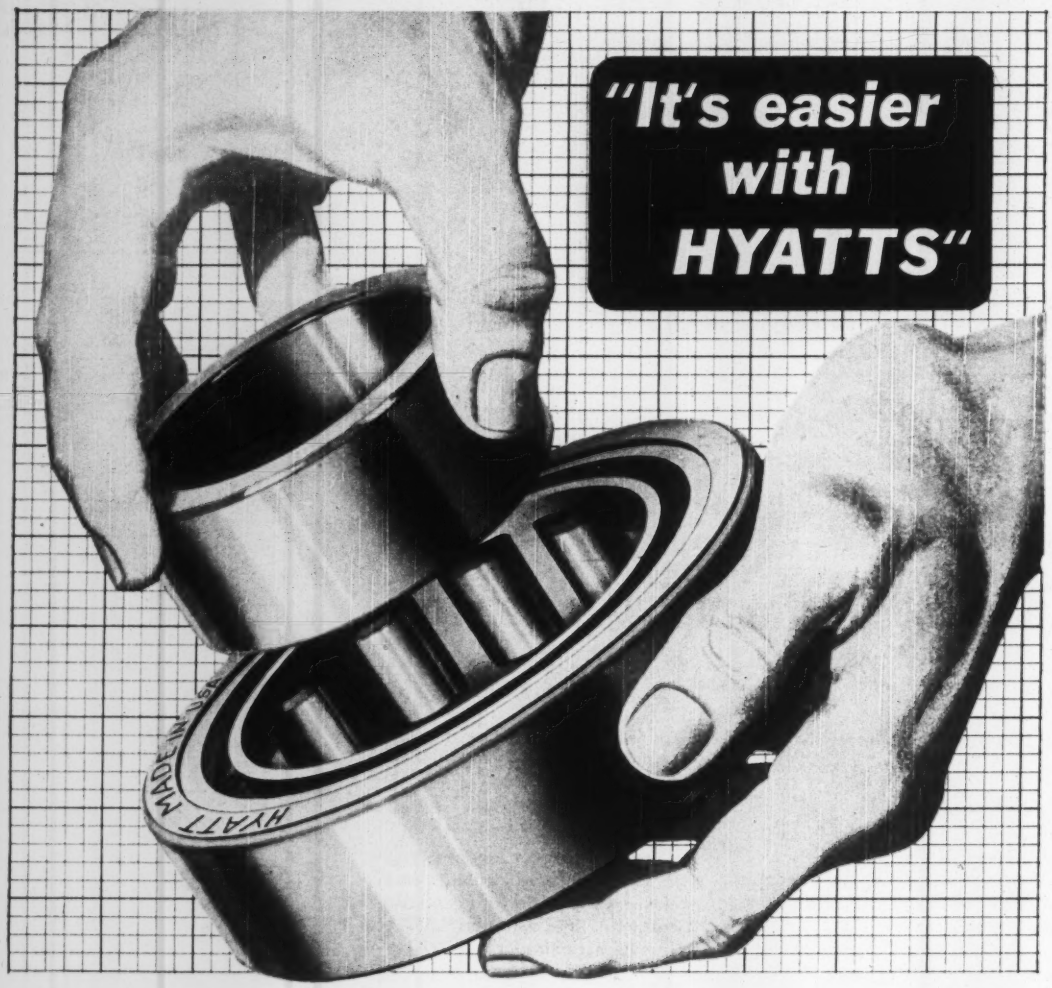
Using the new Kodagraph Projection Papers, you can enlarge small-scale negatives of drawings and documents to original size or larger . . . get high contrast reproductions.

With Kodagraph or Recordak Micro-File Equipment, you can reproduce the most detailed drawings, charts, etc.—"de-bulk" them 98% . . . and protect your valuable originals.

This same ability to reproduce detail exactly, completely, lastingly . . . even to improve its quality . . . gives photography a multitude of uses in your plant. It can help make your designs faster, your production methods smoother, and get your product to the dealer's sooner.

Eastman Kodak Co., Rochester 4, N. Y.

Advancing industrial technics—Functional Photography



Because all separable parts are interchangeable

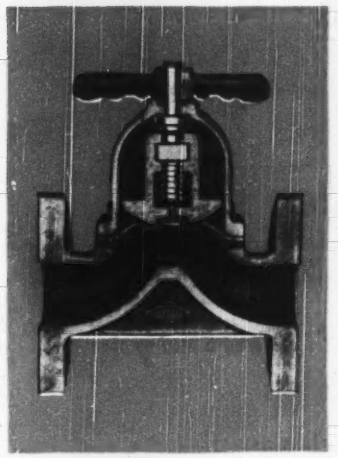
Any inner race or outer race will fit any roller assembly of the same piece number. This eliminates selective fitting and permits you to assemble the separable bearing parts in different machine elements and then bring the elements together, fully confident that all bearing parts will match.

Add to this the fact that Hyatt Hy-Load Roller Bearings are available in a full range of sizes and ten major types, and you have some idea of the wide flexibility of product design and assembly procedures made possible by the use of Hyatts.

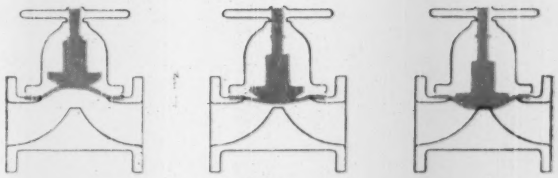
• • •

If you are designing something new, or redesigning an existing product, reach for a Hyatt catalog and see for yourself why "It is easier with Hyatts." Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

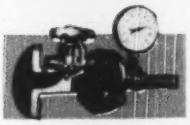


If you need a diaphragm valve you need all the advantages of diaphragm closing



Check these popular features of

GRINNELL-SAUNDERS DIAPHRAGM VALVES



Diaphragm gives leak-tight closure against grit, scale, solid matter . . . Even when something as substantial as an 8-penny nail is trapped on the weir of a rubber lined valve, as illustrated, the resilient diaphragm, plus the large area of contact, gives leak-tight closure against pressure or vacuum.

Diaphragm lifts high for streamlined flow in either direction . . . Smooth, streamlined passage, without pockets, prevents trapping of sludge and reduces frictional resistance to a minimum—irrespective of direction of fluid flow. No disc holder in fluid stream. Grinnell-Saunders Diaphragm Valves are self-draining when installed with the spindle at 15 degrees above the horizontal position.

Diaphragm absolutely isolates working parts from fluid . . . There's no "if" about the way a continuous, one-piece diaphragm seals off the working parts from fluids; no perforation or puncture in the diaphragm where fluid or gas can possibly leak by the valve spindle. No sticking, clogging or corroding of working parts. Valve lubricant cannot contaminate the fluid in the line.

Diaphragm, body and lining materials to meet particular conditions . . . Bodies stocked in cast iron, malleable iron, stainless steel, bronze and aluminum: other materials on special orders. Valve bodies lined with lead, glass, natural rubber or neoprene. Diaphragm materials of natural rubber or synthetics. Working pressure, 150 lbs.; maximum temperature, 180°F.

Diaphragm is only part that normally wears and needs replacement . . . Depending on the type of service, it may last for years, particularly since the compressor and finger plate combine to support the diaphragm in all positions. The diaphragm can be replaced quickly without removing valve from line. No refacing or reseating. No disc holder to require tightening or replacing. No packing glands to demand attention.

Write today for the new Grinnell-Saunders Diaphragm Valve Catalog 4-S.

GRINNELL

Grinnell Company, Inc., Providence 1, R. I. Warehouses: Atlanta • Buffalo • Charlotte • Chicago • Cleveland • Cranston • Fresno • Kansas City • Houston • Long Beach Los Angeles • Milwaukee • Minneapolis • New York • Oakland • Philadelphia • Pocatello • Sacramento • St. Louis • St. Paul • San Francisco • Seattle • Spokane

Better start doing this to part of your money

YOU KNOW how money is!

Today it's in your hand, and the next day it *isn't!*

A lot of people, however, have found an excellent way to make certain they will have money when they need it most.

They *salt* away part of their pay each week in U. S. Savings Bonds through the Payroll Savings Plan where they work.

They know that saving this way assures them of the money for a down payment on a new home . . . a new car . . . or retirement when the time comes.

Furthermore, in ten years they get back $4 for every $3 invested in U. S. Savings Bonds.

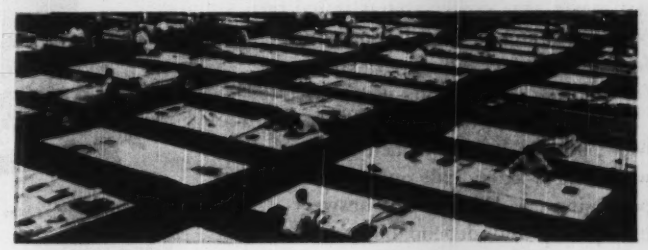
Why don't *YOU* start saving money *regularly* and *automatically* where you work, or at your bank through the Bond-A-Month Plan?

Automatic saving is sure saving — U.S. Savings Bonds

Contributed by this magazine in co-operation with the Magazine Publishers of America as a public service.

A $75,000 per year saving in the making . . .

Streaming off this continuous processing machine at the Ford Motor Company . . . are Kodagraph Autopositive prints—positive photographic intermediates of original drawings. *The answer to a $75,000 per year redrafting headache!*



Before . . . Ford's valuable original drawings had a short life . . . had to do double duty in the drafting room and in heavy print production. In the latter operation, they were exposed to machine wear and tear, constant handling. Soon they lost their detail . . . produced illegible blueprints . . . which meant that new drawings had to be ordered from the drafting room.

Now . . . Ford's originals are filed away in the drafting room after Kodagraph Autopositive intermediates are made—available for reference and revisions only! All blueprints are produced from the "Autopositives," whose photographic black lines will not smudge or lose opacity . . . assuring highly legible prints even after hundreds of "run throughs." As a result of this simple change in routine, *redrafting costs are reduced by an estimated $75,000 per year . . . while the output of creative drafting is increased.* And print production is simplified, too . . . for Kodagraph Autopositives are not only longer-lasting . . . but can be printed at uniform, practical machine speeds.

Kodagraph Autopositive Paper

"The Big New Plus" in engineering drawing reproduction

You, too, can cut your drafting costs, get improved legibility, and simplify print production . . . by reproducing your drawings on this new, low-cost photographic intermediate paper.

You can turn out "Autopositives" quickly, economically . . . with your present print-making equipment and standard photographic processing. Or else you can order them from your local blueprinter. *It will pay you to get all the facts soon!*

MAIL COUPON FOR FREE BOOKLET

EASTMAN KODAK COMPANY
Industrial Photographic Division
Rochester 4, N. Y.

16

GENTLEMEN: Please send me a copy of your illustrated booklet giving all the facts on Kodagraph Autopositive Paper.

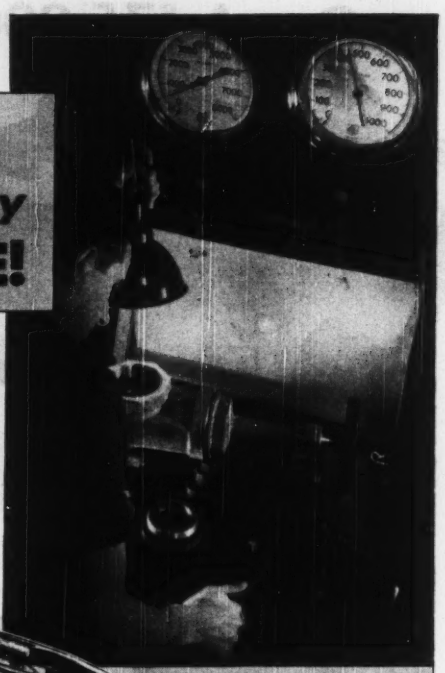
NAME_____ POSITION_____
(please print)

COMPANY_____ STREET_____

CITY_____ STATE_____

Kodak
TRADE-MARK

Gruelling tests... an essential part of every LUNKENHEIMER VALVE!



RIGID TESTING, far above the usual practice, is regular procedure in the production of Lunkenheimer Valves. From selection of raw materials to final assembly, nothing is left to chance or guess. Each and every operation is gauged to meet the high quality standards which assure dependable performance, longer service life and minimum upkeep.

In gate valves, for example, a Lunkenheimer final test means that *every* valve is tested on both sides, at high and low pressure for seat tightness and then given a careful shell test. Spot testing is not tolerated.

This may be producing valves the "hard way", but for Lunkenheimer, it's the only way since it safeguards our proudest possession . . . the mark of unswerving quality and dependability.

ESTABLISHED 1862

THE LUNKENHEIMER CO.

—"QUALITY"—

CINCINNATI 14, OHIO, U.S.A.

NEW YORK 13 · CHICAGO 6 · BOSTON 10 · PHILADELPHIA 34

EXPORT DEPT. CINCINNATI 14, OHIO, U.S.A.

Fig. 2150

150 lb. S.P. Bronze Gate

Like three valves in one. Number 2150 Double Disc, or Number 2151 Solid Wedge Disc, Rising Stem; or Number 2153 Single Wedge Disc, Non-rising Stem. How to convert one type to another by a simple interchange of trimmings is fully explained in Circular Number 574 available from your Lunkenheimer Distributor or direct.

Continually improved testing equipment, together with superior metallurgy and the most modern production equipment assures longer and trouble-free operation, making Lunkenheimer Valves cost less per year of service.

Another assurance of better valve service

In the event of valve trouble, you need and can depend upon, quick service from your Lunkenheimer Distributor. His stocks and facilities shorten production tie-ups, save you dollars and hours. Whether it's an emergency, routine maintenance or new installations, phone your Lunkenheimer Distributor for fast, dependable service.

Leadership through Achievement!

Makers of the NEW UNIVERSAL COFFEEMATIC

POUR THEMSELVES A

YEARLY SAVING of over $10,000.

ON ANNEALING COSTS

To pickle and anneal the body of their new coffee pot was costing Landers, Frary & Clark, makers of the famous line of Universal appliances, $7.50 per M pieces. 5 anneals, which at first seemed necessary to produce the quality product for which Universal is nationally known, jumped the cost per M pieces to $37.50. Universal knew this was far too high and decided to do something about it.

Their metallurgist, in cooperation with Revere, studied the problem in detail and then proved their conclusions by exhaustive tests. It was found that by using Revere copper strip in a certain temper, 4 anneals could be eliminated. Now, after a draw of 7¾", the copper body is annealed once then spun into its finished shape. Based on current production, this has resulted in a saving of over $10,000.00 per year, plus an improved product. Additional savings also are realized through more simplified handling, and more economical finishing operations due to the reduction in the number of anneals.

To make such a deep draw whlle holding rejects to the absolute minimum would not be possible were it not for the fine quality and consistent uniformity of the gauge and temper of the copper used. The copper body is tin plated inside, while the outside is first nickel plated then chromium plated.

Because of the nature of this appliance, which makes coffee automatically to the individual's taste, then reduces the current to keep coffee at serving temperature, Revere copper was selected for its high thermal-conductivity. This makes it possible to brew the coffee faster and keep it hot longer, thus saving on current.

Perhaps Revere Copper or some other Revere Metal can be of help in developing or improving your product—cutting your production costs. Why not tell Revere about *your* metal problems? Call the Revere Sales Office nearest you today.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.
Sales Offices in Principal Cities, Distributors Everywhere.

Engineers' Reference Books

Published by
The American Society of Mechanical Engineers

UNIFIED AND AMERICAN SCREW THREADS (B1.1)

A Published 1949. $3.00—It is in this Standard that you will find the dimensions of (1) unified threads on which agreement has been reached between the Standardization Committees of the U. S., Great Britain, and Canada, (2) the American screw threads continued from the 1935 Standard and (3) the several new sizes which have been added to the course and fine thread series.

PLUMBING CODE (P40.7)

B Published 1949. $2.50—This American Standard covers the design, installation, inspection, and performance of plumbing ystems including water supply, distribution, drainage and venting systems, and fixtures and appurtenances.

AMERICAN STANDARD REAMERS (B5.14)

C Published 1949. $1.00—This Revision gives the general dimensions of thirty types of reamers and related tools, also the magnitude and direction of the tolerances including the number of flutes in the various types. All new types of reamers introduced in recent years are included.

GRAPHICAL SYMBOLS

D These pamphlets provide the standard symbols to be used when indicating information on drawings:—

D1	Welding and Instructions For Their Use	Z32.2.1—1949	50¢
D2	Plumbing	Z32.2.2—1949	40¢
D3	Pipe Fittings, Valves and Piping	Z32.2.3—1949	40¢
D4	Heating, Ventilating, and Air Conditioning	Z32.2.4—1949	40¢

1950 UNFIRED PRESSURE VESSEL CODE

E Published 1949. $3.50—These rules are for the design, fabrication, and inspection during construction of carbon and low-alloy steel vessels, including those operating at temperatures below —20F, vessels fabricated primarily by fusion welding, and vessels or part of vessels fabricated by riveting or by closely fitted bolting.

SAFETY CODE FOR MANLIFTS (A90)

F Published 1950. 55¢—This Code covers the construction, maintenance, inspection and operation of manlifts used for carrying plant personnel only.

TEST CODE FOR CENTRIFUGAL, MIXED-FLOW, AND AXIAL-FLOW COMPRESSORS AND EXHAUSTERS

G Published 1949. $1.50—Provides rules for testing of (1) superchargers and axial-flow compressors in which the change in the gas specific weight exceeds 7%, and (2) apparatus handling gases other than air to determine under specified conditions, one or more of the following quantities: quantity of air or gas delivered, pressure rise produced, power required for compression and efficiency of the compressor.

TEST CODE FOR INTERNAL COMBUSTION ENGINES

H Published 1949. $1.50—This Code shows how to test all types of modern reciprocating internal combustion engines, including gasoline engines, gas engines, and oil or duel-fuel engines. Instruments and apparatus required are specified, and directions for reporting data and results obtained are given.

TEST CODE FOR STEAM TURBINES AND APPENDIX TO THE CODE

I Published 1949. $4.00—Code covers performance testing of all types and applications of steam turbines; the instruments and their application; and the methods of measurement. Appendix gives helpful information on reporting test data and results obtained.

INTERNAL COMBUSTION TURBINES

J Published 1949 $2.25.—Consideration is given to world conditions under which gas turbines for land and sea use are being developed, the principal factors influencing the part-load performance of different gas-turbine engine schemes, gas turbine fuel problems, heat-flow in gas turbines, and the three dimensional flow theories for axial compressors and turbines.

BRITISH GAS TURBINE JET UNIT

K Published 1947. $3.00—(No discount allowed)—A valuable discussion of the design and development of centrifugal compressors for aircraft gas turbines, fluid dynamics of and design of axial compressors, combustion in gas turbines, gas turbine engine testing and vibration problems in gas turbine engines, turbine design for simple jet propulsion engine, and developments in high temperature materials for gas turbines.

REPORT ON OIL ENGINE POWER COST—1948

L Published 1949. $2.50—The only published work giving the costs and performance data supplied by 124 oil engine generating stations whose 441 engines generated 721,370,430 net kwhr.

GASEOUS FLUID FLOW IN RELATION TO DIESEL AND INTERNAL COMBUSTION ENGINE DESIGN

M Published 1949. $2.00—This book makes available the information presented by eminent authorities at a lecture course sponsored by the ASME Oil and Gas Power Division on the subjects of cooling of spark ignition engines, reduction in noise of engines, and the fundamentals of air flow in diesel engine manifolds.

DIESEL FUEL OILS

N Published 1948. $3.50—Provides a comprehensive review of current refining techniques, the chemistry and properties of the preferred hydrocarbons used in the Diesel power field, and the theory and fundamental factors affecting the combustion of Diesel fuel oils.

HEAT TRANSFER AND FLUID MECHANICS

O Published 1949. $5.00—Written by leading engineers and scientists, this book presents a fund of valuable information on the fundamental aspects of fluid flow and heat transfer.

DYNAMICS OF AUTOMATIC CONTROL

P Published 1948. $7.50—A detailed treatment of the functional elements of controls and the mathematical method of handling control problems, the components of the control loop, causes of non-linearities, the off-on regulator and its field of application, and the theory of the excursion-dependent periodic controller.

SYMPOSIUM ON THE REHEAT CYCLE

Q Published 1949. $1.50—A timely discussion of design and performance of regenerative reheat steam turbines, and the developments in resuperheating in steam power plants.

MATERIALS HANDLING

R Published 1949. $2.00—Provides considerable useable information on operating economies, modernizing to reduce cost, work simplification; automatic pallet loading, bulk handling, materials handling engineering as applied to equipment layout and operation flow processing.

OPERATION AND FLOW PROCESS CHARTS

S Published 1947. 75¢—An invaluable reference and an ASME Standard on charting practice.

Mail This COUPON Today

A.S.M.E. Publication-Sales Dept.
29 W. 39th St., New York 18, N. Y.

Date.....

Please send the following "circled" books:

A—$3.00	*E—$3.50*	*K—$3.00*	*Q—$1.50*
B— 2.50	*F— .55*	*L— 2.50*	*R— 2.00*
C— 1.00	*G— 1.50*	*M— 2.00*	*S— .75*
D1— .50	*H— 1.50*	*N— 3.50*	
D2— .40	*I— 4.00*	*O— 5.00*	
D3— .40	*J— 2.25*	*P— 7.50*	
D4— .40			

☐ *Payment herewith* *Note—20% discount to A.S.M.E. members*

NAME.....

ADDRESS.....

CITY.....*ZONE NO*.....*STATE*.....

ME-2-50

How Fafnir helps manufacturers

increase the "abuse capacity"

of portable electric tools

Out where men are men and no refreshing coolant flows, portable electric tools show the stuff they're made of. And the job they do miles from a maintenance staff, down the tracks, out on the farm, on the building site and down in the earth proves that manufacturers put plenty of "stuff" in electric tools . . . sturdily built motors, tempered steel gears and shafts, shock-resisting housings and the best ball bearings to transmit the full power of the motor to the spindle. The fact that so many leading manufacturers of electric tools use Fafnir Ball Bearings proves how well Fafnir has worked with these manufacturers in solving their special problems.

Protection of ball bearings from contaminants has been a major Fafnir project. Some of the types most commonly used in electric tools are the felt seal, the Mechani-Seal and the Plya-Seal.

Whatever your specifications for ball bearings, Fafnir can meet them more precisely, simply because Fafnir's experience is not limited to just one or two industries but is industry-wide. The Fafnir Bearing Co., New Britain, Conn.

Fafnir Felt-Seal Ball Bearing has a cartridge type seal, consisting of two metal plates enclosing a felt washer.

Fafnir Mechani-Seal Ball Bearing has a labyrinth seal, to retain grease and lock out dirt. Outer member acts as slinger.

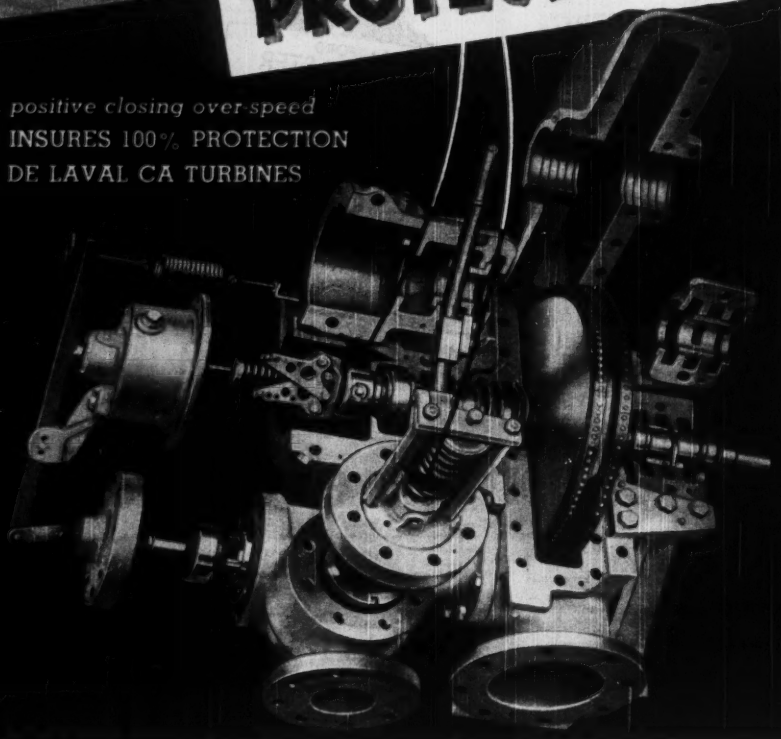
Fafnir Plya-Seal Ball Bearing uses a flexible synthetic washer held in place by stainless steel split retaining ring.

FAFNIR
BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

DOUBLE PROTECTION

Separate, positive closing over-speed
GOVERNOR INSURES 100% PROTECTION
IN NEW DE LAVAL CA TURBINES



The design of the new De Laval CA Turbine assures positive over-speed protection and unfailing emergency shut-off under any and all conditions.

In the CA Turbine, operation of the over-speed governor and emergency trip valve is in no way inter-dependent upon the operation of the normal speed governor or any other part of the turbine. A sticky governor valve cannot jeopardize its operation.

The functioning of the emergency trip valve is quick and sure. The stem of the valve rides freely without packing friction in a closely machined rust-resisting nickel-iron bushing. The valve closes against a single seat with the steam pressure acting on top of the valve to keep it tight. Foreign matter is kept away from the valve seat by a strainer in the steam line.

For double protection, specify the new De Laval CA Turbine.

Before you buy a turbine, be sure and get complete information on these additional De Laval features:

- ✓ True center line support and flexible mounting for perfect alignment.
- ✓ A choice of eight governors.
- ✓ Balanced double-seated bonnet-type governor valves for close control of steam flow.
- ✓ Sensitive, friction-free, wear-resistant "rocking chair" governor pivots. Super-smooth, chrome plated shaft journals make carbon rings last longer.
- ✓ The casing and bearings split horizontally at center line for easy removal and inspection of the rotor, carbon rings and bearings.

SEND FOR CATALOG 4202-22-A

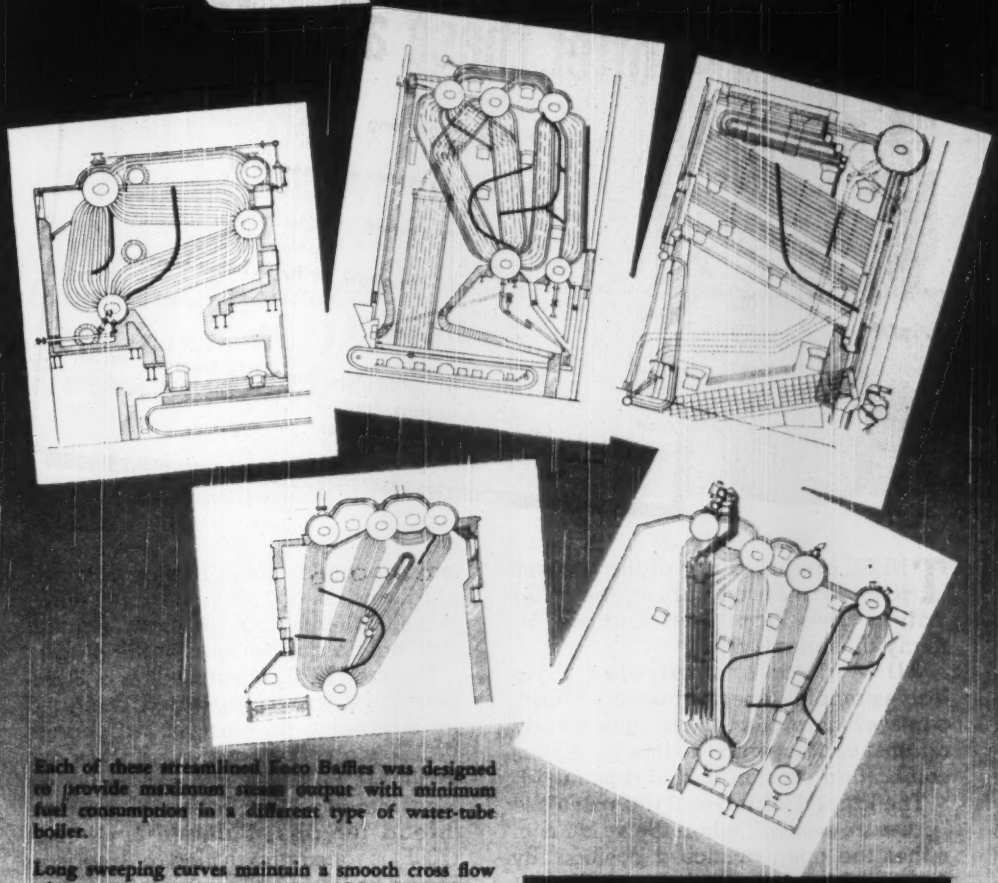
T-22

DE LAVAL STEAM TURBINE COMPANY, TRENTON 2, NEW JERSEY

TURBINES • HELICAL GEARS • CENTRIFUGAL BLOWERS AND COMPRESSORS • CENTRIFUGAL PUMPS • WORM GEAR SPEED REDUCERS • IMO OIL PUMPS

Streamlined for Savings

IN EVERY TYPE OF BOILER



Each of these streamlined Enco Baffles was designed to provide maximum steam output with minimum fuel consumption in a different type of water-tube boiler.

Long sweeping curves maintain a smooth cross flow of gases across every square foot of heating surface. Eddy currents, bottlenecks and dead gas pockets are eliminated—draft losses are cut to a minimum. Soot blowers work more effectively, less steam and less time are needed for cleaning.

Enco Streamline Baffles are individually designed and engineered to the exact requirements of your boiler. Experienced Enco-trained crews take charge of the installation.

The 18-page Enco Bulletin, BW44, shows how engineers throughout industry have gotten higher boiler efficiency and increased steam production through the use of Enco Streamline Baffles. Why not write for your FREE copy today?

The Engineer Company Produces:

ENCO OIL BURNERS

ENCO FUEL OIL PUMPING AND HEATING UNITS

ENCO AUTOMATIC OIL-ELECTRIC IGNITION SYSTEM

ENCO AUTOMATIC COMBUSTION CONTROL

THE ENGINEER COMPANY

75 WEST STREET, NEW YORK 6, N. Y.

Canadian Representative:

F. J. Roskin, Ltd., 370 Rachel E., Montreal, P. Q.

BC-478

WALWORTH LUBRICATED PLUG VALVES

offer these advantages

- . . . Direct port opening
- . . . Quarter turn opens or closes valve
- . . . Dead tight shut-off
- . . . Freedom from attack by fluids being handled
- . . . Pressure sealed
- . . . Made in a complete line. Sizes from ½" to 24" for pressures from 175 to 5,000 psi., and for vacuum requirements

THESE are just a few of the reasons why Walworth Lubricated Plug Valves give "top" performance on many *difficult* services.

All Walworth Lubricated Plug Valves employ special insoluble lubricants which protect the plug and body against contact with the line fluid, thus combatting erosion and corrosion.

The lapped surfaces of the valve are "pressure sealed" when the valve is in either the open or closed position. By turning the lubricant screw, lubricant is forced under high pressure through a grooving system that completely encircles the ports as well as the top and bottom of the plug.

The lubricant seals the valve against leakage, and reduces friction between plug and body. This permits easy, quick, full-opening, or tight shut-off with only a quarter turn of the plug.

Number 1700 (illustrated) is a Steel-iron valve, wrench operated, designed for a working pressure of 200 pounds WOG (water, oil, or gas). Valves are available in either screwed or flange types. Screwed type have API line pipe thread lengths. Flanged type (No. 1700F) is faced and drilled to American Standard for 125-pound cast iron flanges unless otherwise specified.

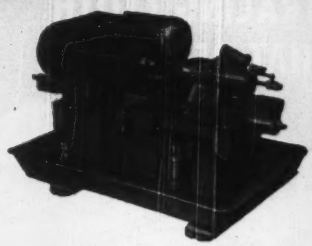
For further information about No. 1700 as well as the complete line of Walworth Lubricated Plug Valves, write for catalog.

WALWORTH

valves and fittings

60 EAST 42nd STREET, NEW YORK 17, N. Y.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD



VARI-PITCH AUTOMATIC SHEAVE AND TEXROPE DRIVE

broadens Application of Gisholt No. 12 Hydraulic Automatic Lathe

Speed Problem Solved!

GISHOLT MACHINE COMPANY had this problem. One of their customers specified an ultra-fine finish when machining various size piston rings which could only be obtained through *stepless adjustable* spindle speed.

Gisholt found the solution in the use of an Automatic *Vari-Pitch* Sheave (5½ in. to 10 in. pitch diameter) and a 14 in. pitch diameter companion sheave.

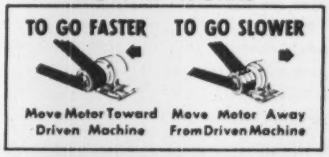
This combination gave them *exactly* the required speeds with instantaneous, simple handwheel adjustment. And because the Automatic *Vari-Pitch* Sheave and drive fitted in the small space, no major changes in design were necessary!

WIDE APPLICATION

Automatic *Vari-Pitch* Sheaves can replace almost any standard sheave on drives from 1½ to 40 hp (special to 60 hp) . . . will give you *stepless* speed changes in a matter of *seconds* . . . overall speed ratios of as high as 2 to 1.

Many designers have already adopted these new sheaves for use on textile spinning frames, centrifugal pumps, farm machinery, various machine tools, and hundreds of other products.

HOW IT WORKS



CHANGE SPEED WITH ONE HAND WHILE MOTOR IS RUNNING

For complete information on diameters and number of grooves, check No. 1 in the coupon below.

ALLIS-CHALMERS, 949A SO. 70 ST. MILWAUKEE *WIS.*

Please send me the literature checked below:

- ☐ 1. *Vari-Pitch* Automatic Sheaves — Section 20-P-50 (Part 4)
- ☐ 2. Handy Guide for Quick Selection of standard *Texrope* Drives — Bulletin (2086051)

Name .....

Title .....

Firm .....

Address .....

City ..... State .....

A-2920

Vari-Pitch and *Texrope* are Allis-Chalmers trademarks.

ALLIS-CHALMERS

ORIGINATORS OF THE MULTIPLE V-BELT DRIVE FOR INDUSTRY

Now you're cooking with **CHACE!**

in the STEVENS ROASTER THERMOSTAT

No. 36—Product of Stevens Manufacturing Co. Mansfield, Ohio

Chace Thermostatic Bimetal, that is. It's the actuating element in the new Stevens Type R thermostat, used for precision control of the Swartzbaugh "Everhot" Roasterette.

Requirements for this thermostat include:

- **Close temperature control**
- **Protection up to 600° F**
- **Positive make and break**
- **Fast response**

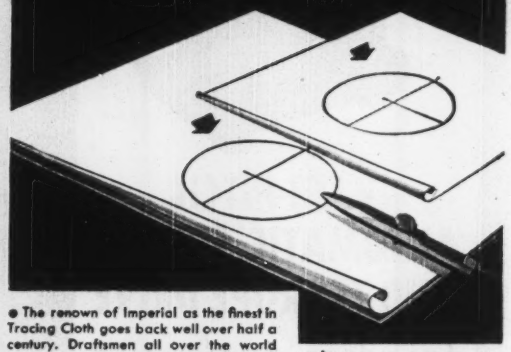
. . . making Chace No. 3600 Bimetal the logical choice for its actuating element! Properties of No. 3600 include high deflection and torque rates, with maximum sensitivity between 200 and 600° F. These qualities make it ideal for this application and other domestic appliances.

Your product, too, is more saleable and more efficient when it's actuated by one of the thirty dependable Chace Thermostatic Bimetals. When designing your new product, or re-designing your present one, Chace application engineers can assist you, through their long experience in the fields of temperature response, indication and control . . . consult them.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1619 BEARD AVE., DETROIT 9, MICH.

TRACING CLOTH THAT DEFIES TIME



• The renown of Imperial as the finest in Tracing Cloth goes back well over half a century. Draftsmen all over the world prefer it for the uniformity of its high transparency and ink-taking surface and the superb quality of its cloth foundation.

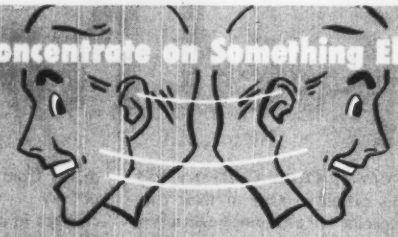
Imperial takes erasures readily, without damage. It gives sharp contrasting prints of even the finest lines. Drawings made on Imperial over fifty years ago are still as good as ever, neither brittle nor opaque.

If you like a duller surface, for clear, hard pencil lines, try Imperial Pencil Tracing Cloth. It is good for ink as well.

IMPERIAL TRACING CLOTH

• **SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE**

Concentrate on Something Else

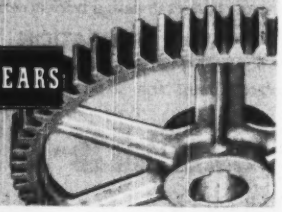


One reason why we're still doing business successfully after forty-five years of manufacturing gears of all types for a variety of industries is because we have continuously maintained the policy of making sure that each customer gets exactly the right gear for the job. Since we expect to continue in business for a great many years, it stands to reason that this policy will never be compromised. Therefore, you can turn your gear problems over to us—while you concentrate on something else.

THE EARLE GEAR & MACHINE CO., 4707 Stenton Ave., Philadelphia 44, Pa. Sales Offices: New York City; Youngstown, Ohio.

EARLE GEARS

It's good business to do business with EARLE.



AFTER 20 MILLION STROKES THESE LINEAR "V" RINGS WERE STILL GOING STRONG!

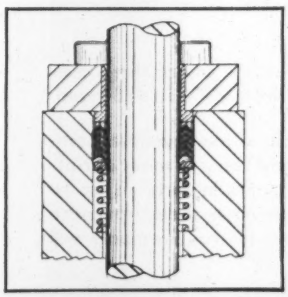
Another Proof-of-the-pudding Demonstration of LINEAR "V" RING Efficiency

This unretouched photograph shows a cut-away section of one of 3 sets of LINEAR "V" Ring packings. Each set was installed at 6-month intervals in a vertical triplex pump operating continuously for a year and one-half under actual service conditions. Throughout the entire 18-month period no maintenance or adjustments were required. When removed, each set was sealing as efficiently as when first installed . . . *and most important, all three sets had identical wear characteristics.*

Spring-loading the packing changed this installation from an adjustable gland to a fixed gland bolted metal-to-metal, thus providing automatic take-up to the packing installation. The result? Complete elimination of dangerous over-tightening of the packing and greatly improved seal life.* By using a spring-loaded installation with style M90 "V" Rings (specified for excellent abrasion resistance) a uniform and predictable packing life was determined from one installation to the next.

LINEAR offers industry a complete line of fabric reinforced and homogeneous "V" type packings for every service. They operate automatically from zero to peak pressures against air, steam, water, gas, oils and solvents over a wide temperature range.

For lowered packing costs and sealing devices of proven dependability, CALL LINEAR.



***PROGRESS REPORT OF SIX-MONTH SERVICE TEST:**

TYPE OF EQUIPMENT: Vertical Triplex Pump.

ROD MATERIAL: Cold drawn Monel.

FLUID PUMPED: River water containing solids of seven grains per gallon.

PACKING: Fabric top adapter with 5 pressure rings homogeneous type (LINEAR M90-V).

METHOD OF INSTALLATION: Packing set used with machined metal adapter installed with a coiled spring with a compression of 5 lbs. per inch of mean circumference for the spring load.

SPEED: 144 four-inch strokes per min.

HIGH PRESSURE: 10,108,980 strokes at 2250 psi.

LOW PRESSURE: 10,108,980 strokes at 0 psi.

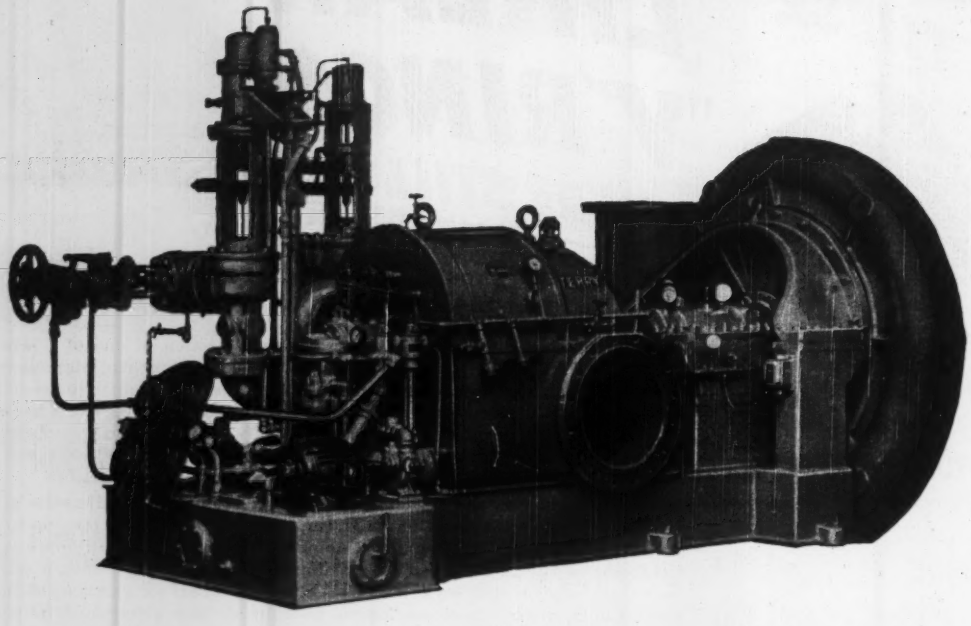
TOTAL STROKES: 20,217,960.

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK STREET, PHILADELPHIA 35, PA.

The TERRY TURBINE



SPECIAL PURPOSE TURBINE

FOR OPERATION UNDER ALL THESE CONDITIONS:

1. Straight, high-pressure, condensing
2. Straight, low-pressure, condensing — putting to work excess low-pressure steam.
3. Mixed pressure — using the low-pressure steam available, with only enough high-pressure steam required to drive the compressor
4. Condensing bleeder operation — providing clean, low-pressure steam for heating or process work

. . . and the speed under any of these conditions can be varied from 2800 to 4750 rpm.

This is but one example of many unusual combinations developed by Terry to meet out-of-the-ordinary requirements in turbines up to 2000 hp. Information on a special-purpose turbine for your specific requirements will be gladly furnished.

T1177

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

GET YOUR COPY

Our new *Unitbilt* Boiler-Stoker Combinations are fully described and illustrated in Bulletin No. SF-1. It contains complete engineering and dimensional data. A copy will be gladly sent upon request. Clip this advertisement or make a memorandum to write us.

The BROWNELL Co.
446 N. Findlay St., Dayton 1, O.

?

IS YOUR COMPANY LISTED
IN THE
·A·S·M·E·
MECHANICAL CATALOG AND DIRECTORY

●

USE YOUR 1950 VOLUME
TO CHECK IF YOUR FIRM IS LISTED

●

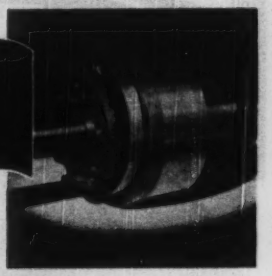
If not listed, write to us upon your Company letterhead, informing us under what product classifications your firm should be listed.

The American Society of Mechanical Engineers
29 West 39th Street, New York 18, N. Y.

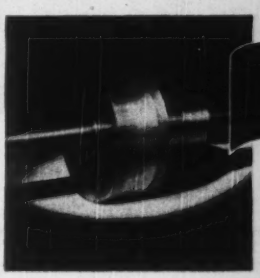
HILLIARD *Clutches*

FOR POWER CONTROL DESIGNS

HILLIARD
SINGLE
REVOLUTION
CLUTCH



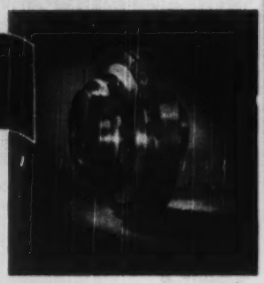
Unequalled for accurate control of intermittent machine operations — cutting, punching, and packaging. Gives closer tolerances to cut-off, stamping, shearing, and similar machines. Completely automatic; manual, mechanical, or electrical control.



HILLIARD
OVER RUNNING
CLUTCH

Hilliard Over-Running Clutches and Couplings are automatic in operation. They are unexcelled for automatic two-speed drives, dual drives, stand-by drives, and for allowing machinery to "coast" after drive stops. Excellent as fixed or infinitely adjustable ratchets.

HILLIARD
SLIP
CLUTCH



A reliable series of spring-loaded slip clutches and couplings. Rugged construction with ample friction surface for heavy-duty use. Outstanding for preventing overloads and shocks; for starting heavy loads; as tension drag brakes; for reeling and winding operations; and many other uses.

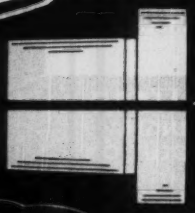
Hilliard's Engineering Department is ready to assist you in designing installations and in selecting the correct clutch or coupling.
Write today — 3 Hilliard Clutch Bulletins with design information. Free on request.

Clutch Makers for over 40 years

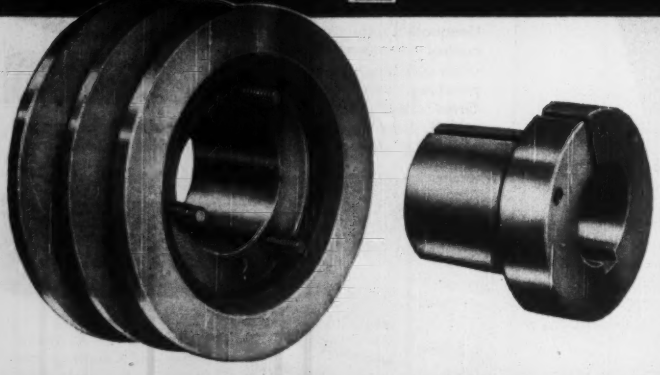
The **HILLIARD** *Corporation*

149 West Fourth Street - - - ELMIRA, N. Y.

Wood's "SURE-GRIP" INTERCHANGEABLE HUB



CUT FROM END TO END FOR MAXIMUM GRIP ON THE SHAFT



Wood's "Sure-Grip" Interchangeable Hub with the "cut" from end-to-end, locks securely with a uniform, full-length grip on the shaft. And because it's easier and faster to mount (simply slide it on, line it up, and tighten), it is a time- and money-saver. To remove, loosen the three bolts and slip it off . . . Wood's engineers will assist you in the selection of a complete drive to fit your requirements.

IN STOCK for immediate delivery . . . a complete range of sizes in A, B, C and D section grooves. Write for detailed information.

T. B. WOOD'S SONS COMPANY, CHAMBERSBURG, PENNA.

Which of These
ROCKFORD CLUTCHES
Will Solve Your Power Control Problem?
Avoid the waste of trial-and-error testing. A letter or phone call to our engineering department will save you weeks of vital time and give you the benefit of their quarter-century of experience transmitting and controlling power — with clutches. Their know-how, plus a wide range of clutch types and sizes to choose from, will help your engineers specify the RIGHT clutch for YOUR product.
ROCKFORD CLUTCH DIVISION
BORG-WARNER
1307 Eighteenth Street, Rockford, Illinois

MECHANICAL ENGINEERING

January, 1950 CARD INDEX Vol. 72, No. 1

May We Co-operate, H. J. Gough	3
We Must Co-operate, J. M. Todd	5
The Attitude of Management Toward Industrial Research, R. E. Wilson	8
The Implication of Federal Support of Education and Research, R. B. Stewart	12
The Anatomy of National Income, M. F. Millikan	15
To ASME Members: The Council Report for 1949	41
1949 ASME Annual Meeting	51
ASME Honors Engineers	77
ASME 1949 Annual Meeting Preprints	84
Briefing the Record	17
ASME Technical Digest	27
Contents of ASME Transactions	40
Comments on Papers	87
Reviews of Books	88
Engineering Profession, News, Notes	92
ASME News	100
ASME Junior Forum	103
Engineering Societies Personnel Service, Inc.	108

For Reference

A 20-PAGE LIST OF A.S.M.E. PUBLICATIONS

is included in the

1950 A.S.M.E. MECHANICAL CATALOG AND DIRECTORY

Copies of the List are obtainable from

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Publications-Sales Dept.

29 West 39th St., New York 18, N. Y.

SEWAREN GENERATING STATION—*Uses..*

(Public Service Electric and Gas Company)

LIMITORQUE VALVE CONTROLS

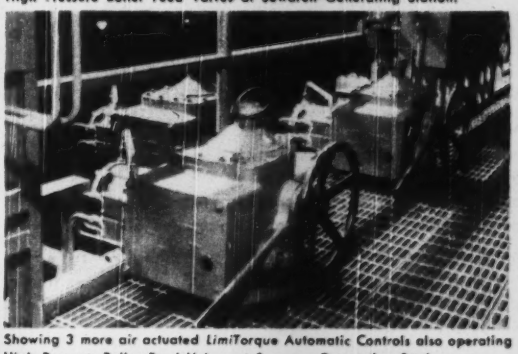
—because they're DEPENDABLE, Safe, Accurate and Trouble-Free

We are very appreciative of the fact that this large, modern Central Station has (like many other modern stations throughout America) installed *LimiTorque Automatic Valve Operators* for their high pressure Boiler Feed Lines, and for sluice gate actuation.

LimiTorque Remote Control enables one man to merely "push buttons" and actually see on a panel-board whether the valves are open or closed. Then too, there is the important safety factor afforded by *LimiTorque Remote Control*, because men do not have to go to high, low, dangerous or inaccessible locations to open and close valves. Further, *LimiTorque* prevents damage to seats, discs, stems, etc., because it "automatically" shuts-off the power, should an obstruction in closing occur.

LimiTorques are available for different requirements on all types of valves (globe, gate, butterfly, plug, etc.) —and may be supplied for actuation by any power source, such as electricity, steam, water, gas, oil or air.

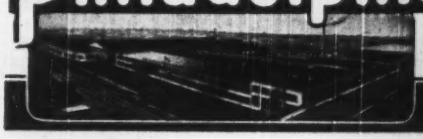
Showing 3 electrically actuated *LimiTorque* Automatic Controls operating High Pressure Boiler Feed Valves at Sewaren Generating Station.



Showing 3 more air actuated *LimiTorque* Automatic Controls also operating High Pressure Boiler Feed Valves at Sewaren Generating Station.

Thousands of *LimiTorques* are in use throughout the world, on land and sea. Be convinced; send for our 96-page catalog, L-48, and please use your Business Letterhead when requesting same.

Philadelphia Gear Works, INC.



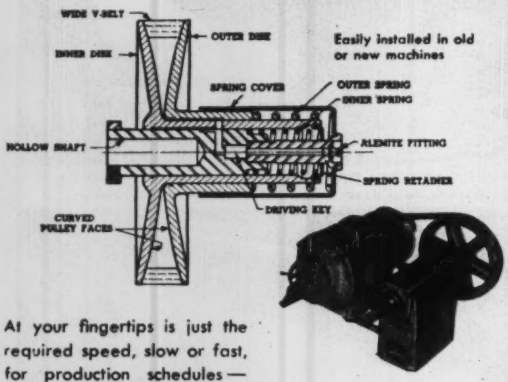
ERIE AVE. AND G ST., PHILADELPHIA 34, PA.
NEW YORK • PITTSBURGH • CHICAGO • HOUSTON
IN CANADA: WILLIAM AND J. G. GREEY LIMITED, TORONTO

Industrial Gears and Speed Reducers — LimiTorque Valve Controls

increase PRESENT CAPACITY of your equipment

with...

LOVEJOY VARIABLE SPEED PULLEYS



Easily installed in old or new machines

At your fingertips is just the required speed, slow or fast, for production schedules — ability of operator — variations in size or parts — variations in density of stock — temperatures. No shutdowns for changing.

All in one compact simple unit, built for longest service — integral part of machine. AT LOW COST. Deliveries from stock. Drives from fractional to 8 h.p. Infinitely variable. Ratios to 3:1.

Manufacturers: Add the strong selling appeal of Lovejoy Variable Speed Pulleys to your equipment.

Send for Complete Catalog showing wide variety of applications.

LOVEJOY FLEXIBLE COUPLING CO.

5032 W. Lake St., Chicago 44, Ill.

Also mfrs. Lovejoy Flexible Couplings, and Lovejoy Universal Joints.

Here—

unusual springs are the usual thing

Combinations or Assemblies as well as intricately formed flat and coiled springs

BGR

BARNES-GIBSON-RAYMOND

DIVISION OF ASSOCIATED SPRING CORPORATION

6400 MILLER AVE. DETROIT 11, MICHIGAN

COOK PLANT • ANN ARBOR, MICHIGAN

Over 1,000,000 NEW kw's from plants using KELLOGG power piping!

ONE million kilowatts of generating capacity require a whale of a lot of power piping. And when you reflect that this volume is confined solely to completed plants and not to piping supplied by Kellogg in the last 25 years, it takes on added significance.

But the actual volume is not so indicative as the reasons behind it. For example, most of these piping installations began on Kellogg's exclusive apparatus for determining stresses in piping layouts . . .

. . . Two called for unusual experience in welding, for they were the first 1050°F. installations employing stainless steel . . .

. . . Another required the fabrication of unique transition pieces in which two metals varying in thermal expansion by 50% were *Kelcaloyed* as single bi-metallic pieces with ends formed of different metals . . .

. . . On several of the jobs availability of experienced supervisors for welding and stress relieving on the site was the key requirement . . .

. . . And all of the installations reflected the results of extended study of such problems as graphitization, creep stress rupture that has been going on for years in Kellogg metallurgical laboratories.

Together these plants, eventually to provide more than one million kilowatts—and those of the past and future—indicate the extra value inherent in Kellogg's participation in the high temperature and pressure piping phase of power plant expansion and construction.

Special studies of unusual problems such as graphitization to assure long life and low maintenance.

Metallurgical research by recognized specialists who have made major contributions in this field.

KELLOGG

M. W. KELLOGG

Exclusive Equipment for accurately analyzing stresses in piping and providing unique data for critical installations.

Complete facilities for the fabrication of steel products from simple forgings to specially cast bi-metallic devices.

Top welding performance in shops and in the field by welders accustomed to working under X-Ray checks.

Quality control, devised by metallurgical experts, embracing forming, heat treating and non-destructive testing

Vessels
Exchangers
Condensers
Process Piping
Forged and Welded Fittings
Radial Brick Chimneys

★

The M. W. Kellogg Company, Inc. (A Subsidiary of Pullman, Inc.) — Offices in New York, Jersey City, Buffalo, Los Angeles, Tulsa, Houston, Toronto, London and Paris.

Micro Ball Bearings

Conrad Radial

The smaller the bearing the better it runs.

In American-made miniature sizes only Micro bearings have *ground* outer rings and raceways.

Write for your copy of Technical Bulletin No. 50 showing RADIAL (Conrad, extra light, and full race), Angular Contact, Self Aligning and Pivot Bearings 1/8" to 3/8" O.D.

New Hampshire Ball Bearings, Inc.

1 MAIN ST. • PETERBOROUGH, NEW HAMPSHIRE

The GROUND Miniature Bearing

WHEN PIPING MOVES

FLEXO JOINTS

Offer the Flexibility of HOSE the Strength of PIPE

Write for complete information

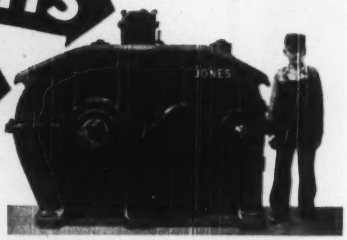
For conveying pressures through moving pipe lines or to machinery or equipment while in motion, use dependable Flexo Joints. Complete 360° movement in either direction for pressures from gravity up . . . long wear—low maintenance cost. Four styles—standard pipe sizes ¼" to 3".

FLEXO SUPPLY CO., Inc.

4652 Page Blvd. St. Louis 13, Mo.

In Canada: S. A. Armstrong, Ltd., 1400 O'Connor Drive, Toronto 13, Ont.

Whether you need THIS —or THIS



You can get what you want in the complete range of Jones Herringbone Speed Reducers

YOU will find this 128-page catalog of Jones Herringbone Speed Reducers helpful in the selection of reducers in accordance with A.G.M.A. recommended practice for all conditions of service. Jones Herringbone Speed Reducers are built in single, double and triple reduction types and in every standard ratio in ratings ranging from 1.25 H.P. to 440 H.P.

All these reducers have heat treated gears, ground shafts and are mounted with anti-friction bearings throughout. Liberal stocks are carried to facilitate shipments.

Catalog No. 70 will save you time and effort in laying out drives that call for Herringbone gears.

WRITE FOR YOUR FREE COPY

W. A. JONES FOUNDRY & MACHINE CO., 4427 Roosevelt Rd., Chicago, Ill.

Jones

HERRINGBONE—WORM—SPUR—GEAR SPEED REDUCERS • PULLEYS
CUT AND MOLDED TOOTH GEARS • V-BELT SHEAVES • ANTI-FRICTION
PILLOW BLOCKS • FRICTION CLUTCHES • TRANSMISSION APPLIANCES

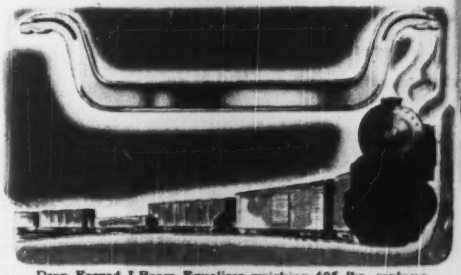
When You Use a *You Have Done All That Can Be Done to Forestall* Unpredictable Parts Failures

Macro-etch through longitudinal cross-section of pinion rack used on power shovel shows fiber-like structure in rack teeth which provides maximum resistance to wear, and strength and toughness for shocks and stresses occurring continually when in use. This fiber-like structure is common in all high quality forgings.

THERE IS NO SUBSTITUTE for the strength and toughness inherent in the forged fiber-like flow-line structure of forgings. The forging method of fabricating parts in closed impression dies directs, controls and concentrates the fiber-like flow-line structure of metals at points of greatest shock and stress. In forgings you obtain the strength and toughness for unrelenting and uninterrupted performance. When you use a forging, you have done all that can be done to forestall the failure of parts and to protect the user of your equipment from unpredictable emergencies. Forgings provide rapid assembly of complex parts as by welding; forgings permit reduction of dead weight because maximum strength and toughness are obtainable in lighter sectional thicknesses. The metal quality and cost-reducing advantages obtainable in forgings cannot be equalled or duplicated. Recheck every stressed part in your equipment, and consult a forging engineer about possibilities for reducing costs of machining and finishing, speeding up assembly and improving performance. Only a forging engineer can inform you fully regarding the many advantages of forgings.

DROP FORGING ASSOCIATION
605 HANNA BUILDING • CLEVELAND 15, OHIO

The steering mechanism of Towmotor lift trucks must operate smoothly at all times and under all kinds of loading without failure. To insure such trouble-free performance, the engineer designed this steering knuckle to be a forging, thereby obtaining a greater factor of safety which is so essential in materials handling equipment.



Drop Forged I-Beam Equalizer weighing 405 lbs. replaces an 800 lb. unit on freight cars. This illustrates how forgings reduce dead weight, yet provide a greater factor of safety that is so important in railroad operation. This drop forged I-Beam requires less machining and processing, and scrap loss is almost totally reduced because forgings are unusually free of concealed defects.

A REFERENCE BOOK ON **FORGINGS** FOR ALL USERS OF METAL PARTS

DROP FORGING *Topics* ISSUED 6 TIMES A YEAR

DROP FORGING ASSOCIATION
605 HANNA BUILDING • CLEVELAND 15, OHIO

☐ Booklet on "Metal Quality—How Hot Working Improves Properties of Metals"

☐ "Drop Forging Topics" which presents numerous end use applications of forgings.

Name _____ Position _____

Company _____

Address _____ City _____ State _____

Edward Presents

Here's a brand-new all-purpose valve series with unusually wide applicability—ideal for almost any service where small O. S. & Y. steel valves are used. Drop forged steel for greatest strength in high pressure or temperature service . . . the simplest packing arrangement imaginable . . . tight, easily accessible union or bolted bonnet joints . . . bronze yoke bushings to prevent stem galling or freezing . . . Microscopically mated seats and disks . . . lock welded parts to prevent loosening in service . . . EValpak heat-resistant molded premium type packing . . . interchangeability of parts for reduced maintenance inventories . . .

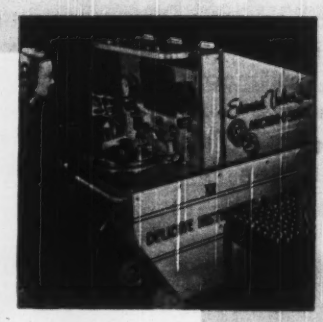
These and dozens of other features are standard in the new Edward Fig. 444 series, now available for stock shipments in most sizes, ⅛ in. to 2 in. inclusive, either 600 or 1500 lb sp.

SIMPLICITY OF PACKING

See how easy it is to repack the new Edward Fig. 444 series. Gland is held on special rests on yoke. Gland bolts swivel out of way, can't come off. Both hands are free to insert packing in generous space between stem and yoke. Pressure-tight backseating for repacking under pressure.

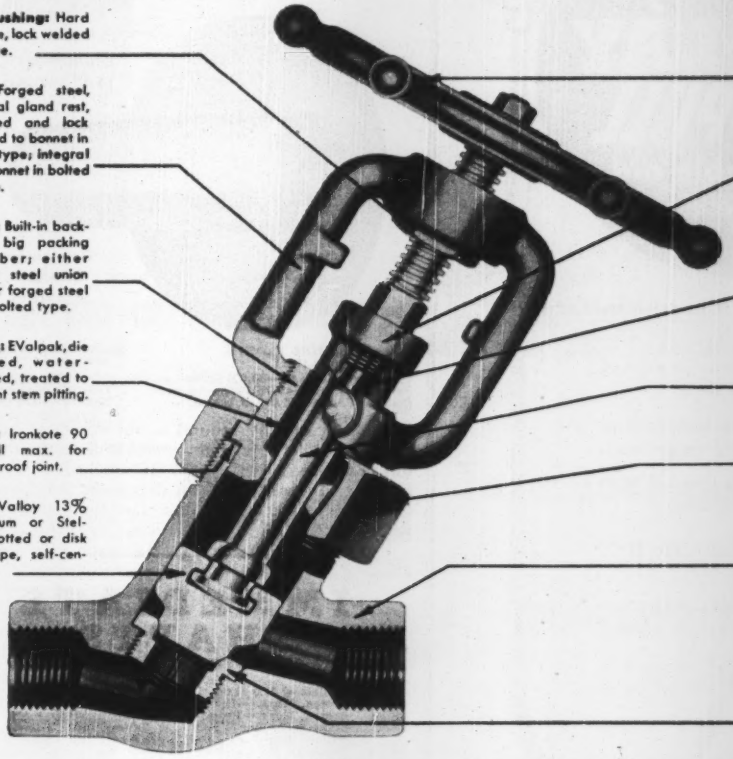
TIGHTEST SEAT-DISK JOINT

No valve is better than its seat-disk joint. All Edward Fig. 444 seats and disks are precision borized to identical angles in mated pairs, then tested on Edward built Micron-o-scope, measuring to .00025 of an inch, for absolute tightness and concentricity.



The All-Purpose Steel Valve!

NEW FIG. 444 SERIES!



Yoke Bushing: Hard bronze, lock welded to yoke.

Yoke: Forged steel, integral gland rest, screwed and lock welded to bonnet in union type; integral with bonnet in bolted design.

Bonnet: Built-in backseat, big packing chamber; either rolled steel union ring or forged steel stud bolted type.

Packing: EValpak, die formed, waterproofed, treated to prevent stem pitting.

Gasket: Ironkote 90 Brinnell max. for leak-proof joint.

Disk: EValloy 13% chromium or Stellite, slotted or disk nut type, self-centering.

Handwheel: Malleable iron, knobbed for easy gripping.

Gland: Forged steel, through bolted, accurately fitted to stuffing box.

Swing Gland Bolts: Forged steel, EValized for longer, corrosion-free life; swivel out of way but can't come off.

Stem: Hardened, centerless ground EValloy, with backseating shoulder (on disk nut on larger sizes).

Union Ring: Rolled or forged steel, hexagonal.

Body: Heat treated forged steel, inclined stem globe type for lowest pressure loss, screwed or socket welding ends.

Seat: EValloy 13% chromium or Stellite on stainless steel; borized in mated pair with disk.

EDWARD VALVES, INC.,
1492 West 145th St., East Chicago, Indiana

Please send a copy of Bulletin 501 describing your new Fig. 444 all-purpose forged steel valves.

Name _____

Company _____

Address _____

City _____ Zone ____ State _____

NOW READY! New Bulletin 501 gives you dimensions, ratings, full data on the new Edward Fig. 444 series. Send coupon now for your copy.

Edward Fig. 444 socket are built in sizes ⅛ to 2 in. inclusive, globe or angle, screwed or socket welding ends, 600 or 1500 lb sp classes, in carbon or chromium molybdenum steel.

Another Product

Edward Valves, Inc.

Subsidiary of ROCKWELL MANUFACTURING COMPANY

EAST CHICAGO, INDIANA

Here's why

TRU-LAY PUSH-PULL

is a valuable aid in machine design

TRU-LAY Push-Pull is precision-made. Therefore it . . .

. . . is positive in action as a steel rod, yet flexible as wire rope

. . . transmits action over long or short lengths, with few or many bends

. . . will operate while flexing, with practically no lost motion

. . . is made in capacities up to 1000 pounds input

. . . is designed for long life—a machine part—not a flimsy gadget

MAIL THE COUPON BELOW

(to our Detroit Office) for bulletin of information about TRU-LAY Push-Pull.

6-235 General Motors Bldg., Detroit 2
•
1119 Santa Fe Avenue, Los Angeles 21
•
Bridgeport, Conn.

ACCO

AUTOMOTIVE AND AIRCRAFT DIVISION
AMERICAN CHAIN & CABLE

Please send me copy of descriptive bulletin DH-87-M-1.

Name_____

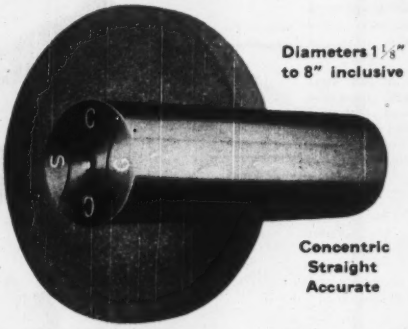
Company Name_____

Address_____

City_____ Zone____ State_____

CUMBERLAND GROUND SHAFTS

An Exclusive Product Made by an Exclusive Method



Diameters $1\frac{1}{8}$" to 8" inclusive

Concentric
Straight
Accurate

MINIMUM ELASTIC LIMIT	MAXIMUM LENGTHS MANUFACTURED
Cumberland Brand—30,000 lb. per. sq. in.	Year 1845—up to 16 ft.
Potomac Brand—45,000 lb. per sq. in.	Year 1886—up to 25 ft.
Cumsoo Brand—55,000 lb. per sq. in.	Year 1945—up to 70 ft.

They are carefully ground to our standard manufacturing tolerance, plus nothing to minus .002" on diameters 1-1/8" to 2-7/16" inclusive . . . plus nothing to minus .003" on diameters 2-1/2" to 8" inclusive. Closer tolerance can be furnished, if desired.

IMMEDIATE SHAFTS

DISTRIBUTED BY

Baltimore, Maryland—Addison Clarke & Bro.
Boston, Mass.—Hawkridge Brothers Company
Boston, Mass.—Brown-Wales Company
Bridgeport, Conn.—Hunter & Havens, Inc.
Buffalo, New York—Jos. T. Ryerson & Son, Inc.
Charlotte, No. Carolina—Edgecomb Steel Co.
Chicago, Ill.—Central Steel & Wire Co.
Cincinnati, Ohio—Jos. T. Ryerson & Son, Inc.
Cleveland, Ohio—The Bissett Steel Company
Dayton, Ohio—Central Steel & Wire Co.
Detroit, Michigan—Central Steel & Wire Co.
Fort Worth, Texas—C. A. Fischer
Hartford, Conn.—Hunter & Havens, Inc.
Indianapolis, Ind.—Tanner & Company
Jersey City, N. J.—Jos. T. Ryerson & Son, Inc.
Lakeland, Fla.—Mine & Mill Supply Co.
Los Angeles, Calif.—Link-Belt Co., Pacific Div.
Louisville, Ky.—Neill-La Vielle Supply Co.
Martinsburg, W. Va.—W. H. Heiston & Son
Montreal, Can.—Drummond, McCall & Co., Ltd.
New Orleans, La.—R. J. Tricon Co.
New York City, N. Y.—Bright Steel Corp.
Oakland, Calif.—Link-Belt Co., Pacific Div.
Philadelphia, Pa.—Charles Bond Company
Philadelphia, Pa.—Horace T. Potts Co.
Pittsburgh, Pa.—McKee-Oliver, Inc.
Portland, Maine—W. L. Blake & Company
Portland, Oregon—Link-Belt Co., Pacific Div.
Providence, R. I.—Congdon & Carpenter Co.
San Francisco, Calif.—Link-Belt Co., Pacific Div.
Seattle, Wash.—Link-Belt Co., Pacific Div.
Spokane, Wash.—Link-Belt Co., Pacific Div.
Toronto, Canada—Drummond, McCall & Co., Ltd.
Worcester, Mass.—Pratt & Inman

CUMBERLAND STEEL COMPANY

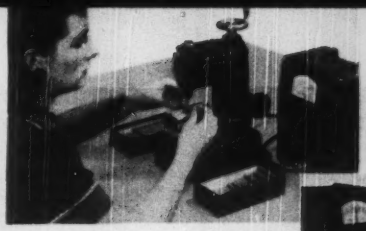
CUMBERLAND, MARYLAND, U.S.A.

ESTABLISHED 1845 INCORPORATED 1892

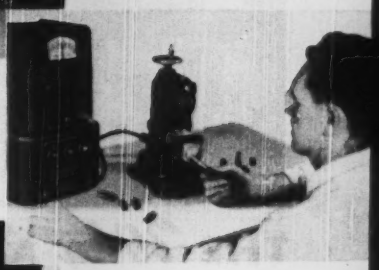
ELECTRONIC MEASURING EQUIPMENT

This equipment provides a reliable means for taking external and internal measurements with precision and ease that advance accurate manufacture and size control. By a simple turn of graduation selector, tolerances can be checked from "tenths" to "hundredths".

Exclusive advantages: any graduation value between .0001" and .00001" . . . separate amplifier completely isolates heat-producing elements . . . true linear response of amplifier permits accurate setting for entire scale with only 1 gage block . . . amplifier may serve several separate testing instruments.



External comparator with range of 0-4". Simplified setting. One master only. Reversible anvil. Self-checking. Shock-protected. Diamond gaging point.

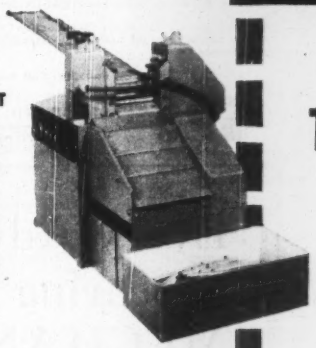


Internal comparator attachment for use with external comparator and amplifier . . . range ½" to 2". Frictionless. No parts to wear. Only one master.

Gage head cartridge for mounting in jigs, fixtures or similar testing pieces. Measurement range .002". Frictionless. Dust and moisture proof.

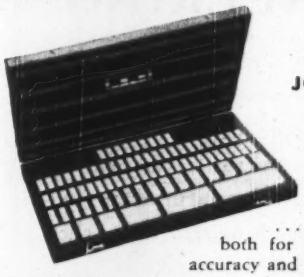
ELECTRONIC INSPECTION AND SORTING EQUIPMENT

Unique design . . . manual loading and disposal to fully automatic . . . custom-engineered at Brown & Sharpe to meet individual requirements. Simplification of parts and functions makes machines more compact, more dependable.



Take your cost cutting cue from this *QUALITY CONTROL EQUIPMENT*

With any one of these modern quality control devices, you can lay the foundation for an efficient, cost-cutting quality control program. Each device offers thoroughly-proven features that broaden the advantages of quality control. All reflect the high precision standards associated with the Brown & Sharpe name. For complete details, write Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

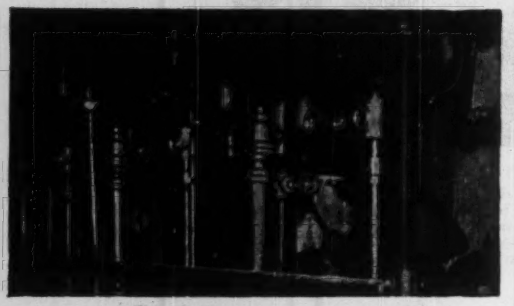


JOHANSSON GAGE BLOCKS

. . . world famous both for their extreme accuracy and for their fast-growing importance to manufacturing of interchangeable parts. These precision aids to quality control are made by Brown & Sharpe; from single blocks to complete sets and useful accessories. Jo-Blocks have hundreds of cost-saving uses.

We urge buying through the Distributor

BROWN & SHARPE



THE *Why* AND *How* OF AIR VENTING

There are two vital reasons why air should be removed at the point where it collects.

First—an air steam mixture always has a lower temperature than pure steam at the same pressure. Steam temperature at 15 psi is 249°F, but mixing 50% of air would reduce this to 212° F, equivalent to 0 psi pressure.

Second; and more serious, the air collects on the heated surface and insulates it from the hot steam, reducing output.

THE SOLUTION

First, select the right steam trap. The Sarco No. 9 Thermostatic for instance *is* wide open when cold. It lets all the initial air out fast. Other Sarcos let air out too, but only at the point where they are installed.

So the next step is to put in Sarco Air Vents at suitable spots in the lines—at the farthest point from entry of steam in process equipment—and at many points in your heating lines.

This is a subject of renewed interest because Sarco has recently designed a complete line of vents and made available special technical data on the subject.

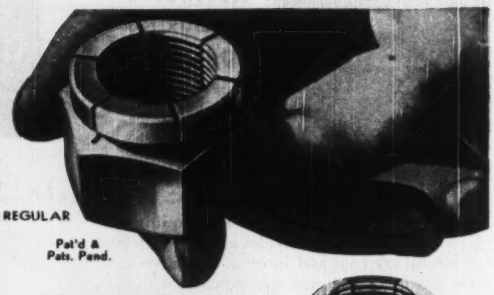
ASK FOR CATALOG No. 275

269

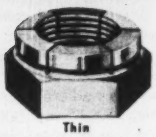
SARCO
SAVES STEAM

SARCO COMPANY, INC.
Represented in Principal Cities
Empire State Building, New York 1, N.Y.
SARCO CANADA, LTD., TORONTO 5, ONTARIO

IMPROVES PRODUCT QUALITY AND OUTPUT



FLEXLOC



ONE-PIECE SELF-LOCKING NUTS

. . . WON'T SHAKE LOOSE!
. . . ELIMINATE "NUT" TINKERING!
. . . REDUCE MAINTENANCE COSTS!

Every day we learn of more FLEXLOC Self-Locking Nuts being used in industry because they are superior fasteners and reduce maintenance costs. Maintenance men are quick to see the value of a nut that the most chattering vibration won't budge, yet which can be removed easily when desired. And in addition, the strong, one-piece FLEXLOC has no extra parts to lose or forget.

So, why not try FLEXLOC Self-Locking Nuts for your maintenance? Find out for yourself how they eliminate "tinkering" with plain nuts and save valuable maintenance time.

Send for samples and our Catalog 619-A.

SPS STANDARD PRESSED STEEL CO.
JENKINTOWN 20, PENNSYLVANIA

Every Advertiser appearing in MECHANICAL ENGINEERING believes . . . .

that his products . . . the service in them and the service behind them . . . will stand up under the most searching scrutiny of the high calibre engineers and executives comprising MECHANICAL ENGINEERING readership.

Representatives—Sales Agencies
Business for Sale
Partnership—Capital
Manufacturing Facilities

OPPORTUNITIES

Positions Open—Positions Wanted—Equipment, Material, Patents, Books, Instruments, etc. Wanted and For Sale

Answers to box number advertisements should be addressed to given box number, care of "Mechanical Engineering," 29 West 39th St., New York 18, N. Y.

POSITIONS OPEN

RATES Classified Advertisements under this heading in MECHANICAL ENGINEERING are inserted at the rate of $1.25 a line. $1.00 a line to members of ASME. Seven words to the line average. A box number address counts as one line. Minimum insertion charge, 5 line basis. Display Advertisements carried in single column units of multiples of one inch at flat rate of $20 per inch per insertion. Maximum size: 1 column, 10 inches deep; 2 columns, 5 inches deep. Copy must reach us not later than the 10th of the month preceding date of publication.

POSITIONS OPEN

for

SENIOR RESEARCH ENGINEERS and PHYSICISTS

Established Electronic and Control Laboratory in the Los Angeles, California area, offers exceptional opportunities for Senior Engineers and Physicists having outstanding academic background and experience in the fields of:

- Microwave Techniques
- Moving Target Indication
- Servomechanisms
- Applied Physics
- Gyroscopic Equipment
- Optical Equipment
- Computers
- Pulse Techniques
- Radar
- Fire Control
- Circuit Analysis
- Autopilot Design
- Applied Mathematics
- Electronic Subminiaturization
- Instrument Design
- Automatic Production Equipment
- Test Equipment
- Electronic Design
- Flight Test Instrumentation

Salaries commensurate with ability, experience and background. Working conditions and opportunities for advancement are excellent. Send information as to age, education, experience and work preference to:

NORTH AMERICAN AVIATION, INC.
AEROPHYSICS LABORATORY
Box No. H-3
12214 South Lakewood Blvd.
Downey, California

MECHANICAL ENGINEER

For Mechanical Design and Engineering Studies in connection with Electric Utility work. Should have 15 years' experience in similar work.

Write to: Mechanical Engineer, Pennsylvania Power & Light Company, Allentown, Pennsylvania.

MECHANICAL ENGINEERS

for Research and Development Work

on Chemical Process Equipment and Scientific Instruments. One Senior Engineer with advanced degree and experience required to take charge of important project. Junior Engineers required for assistants. These are permanent positions for engineers of exceptional ability and inventiveness. Salaries open. The Sharples Corporation Research Laboratories, 424 West Fourth Street, Bridgeport, Pennsylvania.

ENGINEERS WANTED

Atomic Energy Research Department of NORTH AMERICAN AVIATION, INC.

Engineers (mechanical, electrical, chemical) with either advanced training or experience are desired to do analytical, design, and development work on nuclear power plants, under direct contract with the Reactor Division of the Atomic Energy Commission.

Please reply by letter to:

North American Aviation, Inc.
Atomic Energy Research Dept.
Box No. D-2
12214 South Lakewood Blvd.
Downey, California

SALES ENGINEERS

Excellent opportunity for several experienced hydraulic sales engineers. Should have five years of selling experience. Openings are with firmly established hydraulic press concern. Must be willing to travel. State experience.

Address CA-3120, care of "Mechanical Engineering."

MECHANICAL ENGINEER—wanted for plant layout, machine design and process engineering, capable of design and drafting work. Permanent position with advancement for qualified man. Paper or board mill experience desirable but not essential. Give complete information in first letter including references and salary requirement. Address CA-3072, care of "Mechanical Engineering."

DESIGN ENGINEERS—Civil, Mechanical and Structural. Openings for Qualified men with industrial experience in above lines. Give complete information regarding background, age, references, and salary requirements in first letter. Address CA-3095, care of "Mechanical Engineering."

VALVE DESIGNER—For steadily growing Chicago area company. Prefer man with design experience in the steel valve field. This is a board position. Salary commensurate with ability and experience. Address CA-3104, care of "Mechanical Engineering."

Use a CLASSIFIED ADVERTISEMENT *for Quick Results*

ASSISTANT TO CHIEF ENGINEER—Excellent opportunity, with a progressive company in the Chicago area, for a mechanical engineer experienced in valve design. Send details of qualifications. Address CA-3105, care of "Mechanical Engineering."

GRADUATE MECHANICAL ENGINEER—35 to 45 years of age. Superintendent wanted for large shop engaged in fabrication of experimental models to close tolerances. Shop includes engineering staff and is part of well established research organization in vicinity of Washington, D. C.; B.S degree in M.E. and 5 to 10 years' responsible management experience required. References essential. Starting salary approximately $7800 per year. Address CA-3108, care of "Mechanical Engineering."

SALES ENGINEER—experienced in selling centrifugal pumps for work at our Indianapolis home office or Chicago or New York branches. Salary and commission. Write fully regarding qualifications. Address CA-3109, care of "Mechanical Engineering."

DESIGN AND DEVELOPMENT ENGINEER—old established midwest manufacturer desires experienced engineer to design fuel, hydraulic, and pneumatic valves for aircraft. Please give detailed information of practical experience, education, salary desired and pertinent data. Address CA-3112, care of "Mechanical Engineering."

MECHANICAL AND ELECTRICAL ENGINEER—Excellent opportunity for young man with approximately five to ten years' experience in design, specifications and supervision of the mechanical and electrical phases of building construction, with particular emphasis on school and institutional work. Full partnership offered for right man in established engineering office. Location: New England. Address CA-3113, care of "Mechanical Engineering."

MECHANICAL ENGINEER—familiar with air compressor—steam engine or diesel engine details, design and construction—by old established manufacturing company. Prefer man with considerable experience who is now looking for permanent opening offering opportunity for advancement to executive position. Please give full information with salary expected in reply, which will be held completely confidential. Our own men know of this advertisement. Address CA-3114, care of "Mechanical Engineering."

SALES ENGINEERS—Large industrial instrument manufacturer requires the services of engineering graduates, preferably with industrial instrument experience, in the Chicago, Philadelphia, Pittsburgh, Detroit, Cleveland, and Houston Districts. Good opportunity for men with right experience. Men with pneumatic control and electronic potentiometer experience given special consideration. Address CA-3116, care of "Mechanical Engineering."

WANTED, SEVERAL ENGINEERING GRADUATES—under 35, by large industrial fire prevention organization maintained by national insurance group, for field work involving periodic inspections and special consulting service. Permanent. Address CA-3118, care of "Mechanical Engineering."

GRADUATE MECHANICAL ENGINEER—Who has specialized in machine design and development work for five or more years. Working knowledge of dynamics and vibration desirable. Midwest location. Please furnish complete information regarding personal, educational and business background. Address CA-3133, care of "Mechanical Engineering."

SALES ENGINEER—centrifugal pumps for New York and Chicago. Must be thoroughly experienced in this line. Write fully personal and selling history. Salary, expenses and commission. Strictly confidential. Dean Hill Pump Co., Indianapolis 7, Indiana.

POSITIONS WANTED

ENGINEERING EXECUTIVE—B.S.M.E. Member A.S.M.E. Registered Professional Engineer. Twenty years' of varied production experience in the fiberboard container industry desires position as company engineer or plant manager. Prefer to locate in the west. Address CA-3107, care of "Mechanical Engineering."

MECHANICAL ENGINEER—B.S.—Age 30—Position desired as service or erection engineer. Experience with steam boiler plants, refrigeration and diesel engineering. Free to locate where necessary. Address CA-3111, care of "Mechanical Engineering."

EXECUTIVE ENGINEER—E.E., Fellow AIEE, member ASME, 30 years' practical experience, Elec., Mech., Heat Transfer and Metallurgical fields. Experience covers Development, Engineering, Patent, Production, Tools, Costs and Sales Domestic and Foreign. Well acquainted in USA, Canada and Mexico, Utilities and Industrials. Address CA-3115, care of "Mechanical Engineering."

MECHANICAL ENGINEER—31, single, BSME, registered. Eight years' experience in tooling, machine, and product design. Experience includes aircraft, farm tractors, household equipment, utensils, and toys. Has initiative and creative ability. Desires position with future in small company. Midwest or west. Address CA-3121, care of "Mechanical Engineering."

Continued on Page 98

Two Pages of Opportunities This Month . . . 95-96

Continued from Page 95

POSITIONS WANTED

Continued from Page 95

COMBUSTION ENGINEER—Master of Science from University of Illinois. Research experience in fuels and smoke. Desire position dealing with atmospheric pollution control. Address CA-3117, care of "Mechanical Engineering."

AVAILABLE—ENGINEER INVENTOR—with 12 years of electromechanical experience at G.E. Co. in all phases of design and manufacture. Licensed P.E.—commercial pilot. Enthusiastic about results. Authority not mandatory. Open to suggestions. Address CA-3119, care of "Mechanical Engineering."

EXECUTIVE-MANAGEMENT MECHANICAL ENGINEER—desires new connections, preferably in the East. Over 25 years' experience in all phases of Abrasive Manufacture—including engineering, supervision and management. Member of A.S.M.E. and Professional Engineers' license for State of New York. Will consider administrative position or distributorship in field where background is commensurate with requirements. Address CA-3122, care of "Mechanical Engineering."

RESEARCH ENGINEER-PHYSICIST, 37, PH.D.—11 years' experience in mechanics, combustion, fluid dynamics, and electronic and mechanical instrumentation, desires new connection with research or development organization. Address CA 3123, care of "Mechanical Engineering."

MECHANICAL ENGINEER—Cornell graduate; registered Professional Engineer, New York; age 37; married. Fifteen years' experience including testing, inspection, maintenance and administrative duties. Desires responsible position as Assistant to Chief Engineer or Plant Manager. Address CA-3124, care of "Mechanical Engineering."

SENIOR EXECUTIVE ENGINEER—45, possessing rare combination of technical, organizational and administrative capacity with outstanding record as Project Manager and Chief Engineer. Wide experience petroleum, chemical and power plants, also manufacture process, pressure and heat exchange equipment and specialized machinery. Extensive personal adequacy as design, fabrication and materials engineer; inventive, resourceful. Address CA-3125, care of "Mechanical Engineering."

CHIEF ENGINEER—Registered P.E. Mech. A.S.M.E. Would like to locate below Mason-Dixon line. Especially familiar with metal working, mining, milling. Would accept managership of small industrial plant with a future. Address CA-3126, care of "Mechanical Engineering."

MECHANICAL AND CIVIL—graduate engineer, demonstrated competence planning and directing expansion, reconstruction work. Specially well prepared in mechanical equipment, piping and structural steel. Several years as consultant, surveying industrial plants, writing reports, developing and producing complete projects. Professional registration. P. O. Box 189, Elizabeth, New Jersey.

MECHANICAL ENGINEER—BSME—ASME—PE. Age 31. Seven years in chemical industry. Plant layout, piping, pressure vessels, mechanical equipment, machine design, project preparation and estimates. Employed at present in W. Va. Will relocate for opportunity. Address CA-3129, care of "Mechanical Engineering."

GRADUATE MECHANICAL ENGINEER—M.E. Cornell Univ., Member A.S.M.E., family, excellent educational and experience background. 13 years' successful mechanical engineering experience in research, development, design, and testing relating to both process and product activity in the electro-mechanical, structural, machine design, and chemical fields. Able, experienced liaison, supervision, travel, report writing. Desires permanent responsible position with progressive organization where integrity, varied experience, and creative ability will be valued assets. Resumé on request. Address CA-3132, care of "Mechanical Engineering."

MECHANICAL ENGINEERING—Member of A.S.M.E., Age 48, Married. Registered Graduate Engineer, now employed, desires change for a more responsible position as Mechanical or Assistant Chief Engineer. Twenty years of diversified mechanical experience involving Design, Testing, Patent Developments, Inspection, and Administration Duties. Will travel if necessary. Address CA-3134, care of "Mechanical Engineering."

RETIRED EXECUTIVE ENGINEER—desires part time work in New York area—Internal combustion engineering design and production, gas turbines, shop processing, tests, specifications, expert testimony general mechanical problems. N. Y. & N. J. P.E. licenses. Address CA-3135, care of "Mechanical Engineering."

REPRESENTATION WANTED

ENGINEERING SALES REPRESENTATIVES—wanted in principal cities to handle complete, quality line of air and hydraulic cylinders. Write in confidence stating lines now being handled, territory covered and references. Loleen Mfg. Co., 1600 S. San Pedro St., Los Angeles 15, Calif.

EMPLOYMENT AGENCIES AND SERVICE BUREAUS

PLANT PERSONNEL, ENGINEERS, DESIGNERS—Draftsmen, Chemists, and Metallurgists, E. G. Stroud, Member A.S.M.E. and President Cleveland Engineering Agency Co., 2132 E. 9th St., Cleveland 15, Ohio, will help you find positions or men.

SALARIED POSITIONS $3,500-$15,000. If you are considering a new connection, communicate with the undersigned. We offer the original personal employment service (40 years' recognized standing and reputation). The procedure, of highest ethical standards, is individualized to your personal requirements and develops overtures without initiative on your part. Your identity covered and present position protected. Send only name and address for details. R. W. Braby Inc., 115 Dun Bldg., Buffalo, N. Y.

SALARIED PERSONNEL $3,000—$25,000

This confidential service, established 1927, is geared to needs of high grade men who seek a change of connection under conditions, assuring, if employed, full protection to present position. Send name and address only for details. Personal consultation invited.

JIRA THAYER JENNINGS
Dept. J, 241 Orange Street, New Haven Conn.

It will pay you to watch the announcements on these pages for an opportunity that you may be looking for or one that may be of interest to you.

BINDERS FOR ASME LITERATURE

By making use of the following types of binders you will be able to keep your ASME Standards, Codes, Transactions and Technical Papers in handy form.

FOR TRANSACTIONS AND TECHNICAL PAPERS

THREE RING BINDER
Size, 9¼" x 11½", Capacity—2". This binder has a rounded metal back, opening boosters, and stiff cover. $2.50

PRONG BINDER
Size, 9¼" x 11½", Capacity—1". This flexible backed, stiff covered binder is equipped with flexible prongs which are held against the book or sheet by means of two metal slides. $1.75

FOR STANDARDS AND POWER TEST CODES

A specially designed binder which gives every advantage of a bound book together with the added convenience which comes from the ability to insert, remove, and transpose sections of the contents instantly. Its 25 flexible steel rods can be easily slipped out or under top and bottom metal lips. Size, 8½" x 11½", Capacity—2½". $3.25

FOR BOILER CONSTRUCTION CODES

Except for size—6" x 8¼" and capacity—3", this binder is identical with that provided for Standards. $2.75

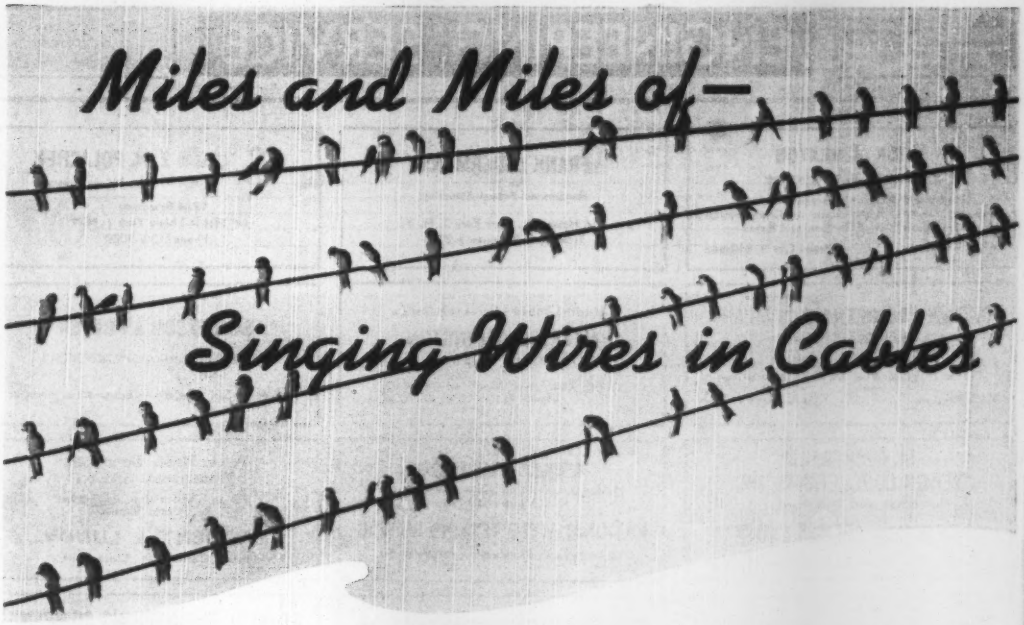
BOILER CODE INTERPRETATIONS

For this material a three-ring binder is available in 5½" x 8" size, with a one inch capacity. $2.00

Binders are issued in attractive durable cloth, and each bear an identifying imprint in gold.

20% discount to ASME Members

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 WEST 39TH STREET, NEW YORK 18, N. Y.

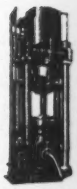


are lead encased by

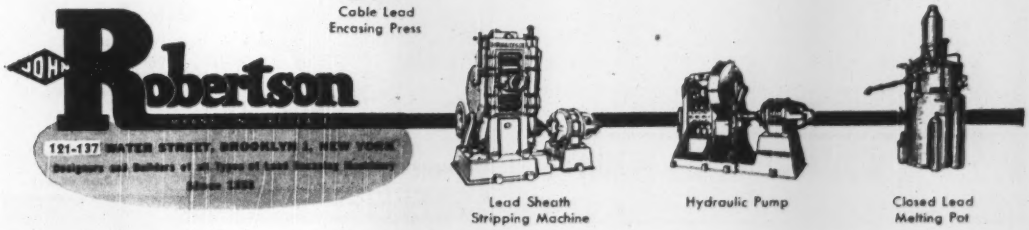
ROBERTSON HYDRAULIC PRESSES

Why? . . . Because Robertson Equipment not only is precision manufactured, but precision engineered to perform specific operations . . . such as producing the world's most widely used lead encased cables with a close fitting lead sheath of maximum density and uniformity, at lower operating and maintenance costs.

Today, Robertson Equipment is the acme of perfection . . . a culmination of over 92 years' specialized experience in designing and building high pressure hydraulic equipment exclusively. Please consult our capable engineers on specific problems.



Cable Lead Encasing Press



Lead Sheath Stripping Machine

Hydraulic Pump

Closed Lead Melting Pot

RATES One Inch Card Announcements inserted at rate of $15.00 per issue, $12.00 per issue on yearly contract.

ENGINEERING SERVICE

Manufacturers of Equipment Not Included

BLACK & VEATCH
CONSULTING ENGINEERS
Electricity—Water—Sewage—Industry
Reports, Design, Supervision of Construction
Investigations, Valuation and Rates
4706 Broadway — Kansas City 2, Missouri

FRANK LEDERMANN
Registered Patent Attorney
154 Nassau St., New York 7, N. Y.
Telephone Beekman 3-2936

Consult **Z. H. POLACHEK**
Reg. Patent Attorney
1234 Broadway
(at 31st St.) New York 1, N. Y.
Phone LO 5-3088

BROWN ENGINEERING COMPANY
Consulting Engineers
Power Plants, Substations, Transmission,
Water Supply, Sewage Disposal, Rates
K. P. Building — Des Moines 9, Iowa

Industrial Power—Surveys & Design
MYERS & ADDINGTON
Consulting Engineers
21 East 40th Street, New York 16, N. Y.
Murray Hill 6-4630

SANDERSON & PORTER
ENGINEERS AND CONSTRUCTORS
New York • San Francisco • Chicago • Los Angeles

M. BUCHSBAUM
DESIGN CONSULTANTS, INC.
Research and Development
Aerodynamics—Structures—Product Design
Electronic Instrumentation
Suite 1017, 521 Fifth Ave., New York 17, N. Y.

WELD TESTING
Qualification of Operators—Supervision
Inspection—Research
NATIONAL WELD TESTING BUREAU
Pittsburgh Testing Laboratory, Pittsburgh, Pa.

Power Plants, Structures,
Transmission Systems
Design, Supervision, Inspection
Appraisals, Reports
SARGENT & LUNDY
140 S. Dearborn St., Chicago, Ill.

THE CARLSON COMPANY
Spring Design Specialists
Mechanical Product Development
277 Broadway — New York 7, N. Y.
Phone: Barclay 7-2552

NEW YORK TESTING LABORATORIES, INC.
Chemical, Electrical, Metallurgical
and Mechanical Engineers
80 Washington Street, New York 6, N. Y.
Bowling Green 9-4414

STANLEY ENGINEERING COMPANY
CONSULTING ENGINEERS
Power Plants
Steam - Diesel - Hydro
Design - Construction - Test - Valuation
Surveys
Hershey Building — Muscatine, Iowa

C. M. HATHAWAY
CONSULTING ENGINEER
Project Engineering, Product Development,
Production Designs, Laboratory and Shop
Facilities for Research, Model Work,
and Pilot Manufacturing
1315 S. Clarkson Street — Denver 10, Colorado

Metallurgists
Analysts **Consultants**
Spectroscopists
PHILADELPHIA TESTING
LABORATORIES
900 W. Vanango Street
Philadelphia 40, Pa.

ST & CO., INC.
DESIGNING
ENGINEERING
Machines • Products • Plants
Processes • Production • X-Ray
SAM TOUR & CO., INC.
44 TRINITY PL., N.Y. 4, N.Y.

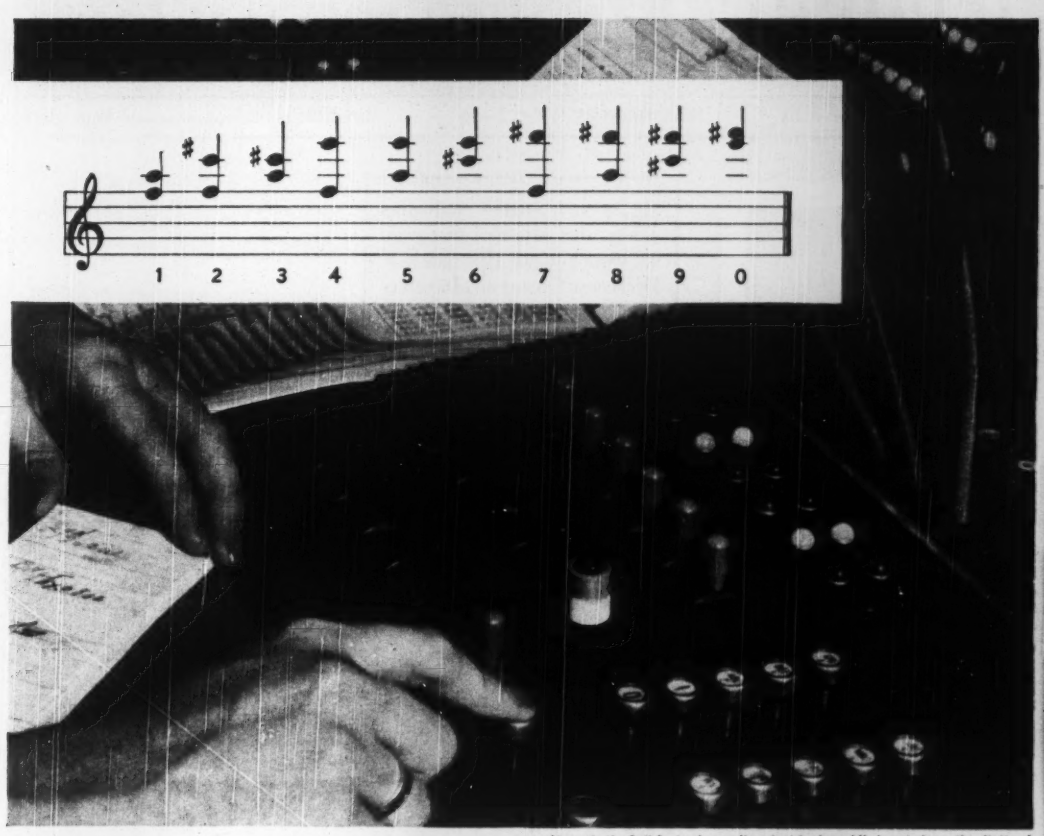
LANCASTER, ALLWINE & ROMMEL
Registered Patent Attorneys
Patent Practice before U. S. Patent Office, Validity and Infringement Investigations and Opinions. Booklet and form "Evidence of Conception" forwarded upon request.
Suite 479, 815-15th St., N.W., Washington 5, D. C.

An announcement in this section will acquaint others with your specialized practice.

Industrial Engineering
Production Equipment, and Machine Design
Management of Industrial Companies
CHARLES M. ZUST COMPANY
Empire State Building — New York 1, N. Y.

MPB makes more than 50 types and sizes of miniature ball bearings
BEARINGS, Ball, miniature. Standard and Special for application in precision mechanisms to minimize friction and wear. High load capacity in minimum space. Light in weight. Specify MPB for shock loads, continuous operation, extreme temperature ranges and delicate responsiveness. Special designs and complete engineering service for your application. Write for catalog M.
MPB
MINIATURE Precision BEARINGS
INCORPORATED
KEENE, NEW HAMPSHIRE, U.S.A.

TROUBLE-FREE
KEWANEE
SCOTTIE JR
• It lasts and lasts and lasts without break-downs. Easy to handle, every part accessible . . it's truly trouble-free. For any fuel
6 to 36 H. P.—100 lbs. W. P.
For 6" Scale with pipe diameter markings . . . WRITE Dept. 99-M2
KEWANEE BOILER CORPORATION
KEWANEE, ILLINOIS



Above is the Bell System's new "musical keyboard." Insert shows the digits of telephone numbers in musical notation, just as they are sent across country.

Playing a tune for a telephone number

Before you talk over some of the new Bell System long distance circuits, your operator presses keys like those shown above, one for each digit in the number of the telephone you are calling. Each key sends out a pair of tones, literally setting the number to music.

In the community you are calling, these tones activate the dial telephone system, to give you the number you want. It is as though the operator reached clear across the country and dialed the number for you.

This system, one of the newest developments of Bell Telephone Laboratories, is already in use on hundreds of long distance lines radiating from Chicago, Cleveland, New York, Oakland and Philadelphia, and between a number of other communities.

It will be extended steadily in other parts of the country — a growing example of the way Bell Telephone Laboratories are ever finding new ways to give you better, faster telephone service.

BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting, for continued improvements and economies in telephone service

Index To Advertisers

KEEP INFORMED—Pages 41-64 ENGINEERING SERVICE—98 OPPORTUNITIES—(classified ads) Pages 95, 96

*Aldrich Pump Co. 57
All American Tool & Mfg. Co. 64
*Allis-Chalmers Mfg. Co. 79
Allis, Louis, Co. 39
*American Blower Corp. 22
*American Felt Co. 3
ASME Publications 74, 96
Arkwright Finishing Co. 62
Automotive & Aircraft Div., American Chain & Cable 92

*Babcock & Wilcox Co. 2nd Cover
Baldwin-Duckworth Div. of Chain Belt Co. 28, 29
*Barco Mfg. Co. 16
*Barnes-Gibson-Raymond, Div. Assoc. Spring Corp. 86
*Barnes, Wallace, Co., Div. Assoc. Spring Corp. 14
Bell Telephone Laboratories 99
Briggs & Stratton Corp. 55
Brown & Sharpe Mfg. Co. 93
*Brownell Co. 83

Carrier Corp. 4
Central Scientific Co. 52
Chace, W. M., Co. 80
Chain Belt Co. 28, 29
Chiksan Co. 60
Clark Equipment Co., Industrial Truck Div. 45
Climax Molybdenum Co. 53
*Combustion Engineering-Superheater (Inc.) 15
Cone-Drive Gears Div., Michigan Tool Co. 19
Cumberland Steel Co. 92

*DeLaval Steam Turbine Co. 44, 76
Dowell (Inc.) 21
*Downingtown Iron Works 52
Drop Forging Association 89

Earle Gear & Machine Co. 80
Eastman Kodak Co. 67, 71
Edward Valves (Inc.) Sub. of Rockwell Mfg. Co. 90, 91
*Engineer Co. 77
*Erie City Iron Works 11

Faber, Eberhard, Peneil Co. 58
*Fafnir Bearing Co. 75
*Farrel-Birmingham Co. 20
Farval Corp. 27
Flexo Supply Co. 88
*Foote Bros. Gear & Machine Corp. 39
*Foxboro Co. 102

Gear Specialties 5
*General Electric Co. 25
General Radio Co. 66
*Goulds Pumps (Inc.) 50
Graphite Metallizing Corp. 53
*Grinnell Co. 69

Hamilton-Thomas Corp. 12
Hathaway Instrument Co. 63
Helicoid Gage Div. American Chain & Cable 49
Hilliard Corp. 83
Hyatt Bearings Div., General Motors Corp. 68
Hydropress (Inc.) 2

★ **The asterisk indicates that firm also has product catalog in the 1950 A.S.M.E. Mechanical Catalog and Directory**

The Only Reference Annual Covering the Mechanical Engineering Field with a Unique Combination of Complete Equipment Directory and Manufacturers' Catalogs Up-to-date 20-page Insert Catalog of A.S.M.E. Publications is Included.

Published Annually By
The American Society of Mechanical Engineers
29 West 39th St., New York 18, N. Y.

Imperial Tracing Cloth 80
International Nickel Co. 34
Irving Subway Grating Co. 52

Jenkins Bros. 40
*Johns-Manville 30
*Jones, W. A., Fdry. & Mach. Co. 88

Kay Electric Co. 51
Kellogg, M. W., Co. 87
Keuffel & Esser Co. 6, 7
*Kewanee Boiler Corp. 98
*Kinney Mfg. Co. 48
Klipfel Valves (Inc.) Div. Hamilton-Thomas Corp. 12

Ledeen Mfg. Co. Div. Engineering Products Co. 58
*Leeds & Northrup Co. 10
Linear (Inc.) 81
*Link-Belt Co. 31
Lovejoy Flexible Coupling Co. 86
Lubriplate Div., Fiske Bros. Refining Co. 47
Lunkenheimer Co. 72

*Mears-Kane-Ofeldt (Inc.) 46
Midwest Piping & Supply Co. 101
*Miniature Precision Bearings (Inc.) 98

*National Airoil Burner Co. 56
New Departure, Div. General Motors Corp. 1
New Hampshire Ball Bearings (Inc.) 88
Nordstrom Valve Div. of Rockwell Mfg. Co. 32, 33

Ozalid Div. of General Aniline & Film Corp. 59

Panoramic Radio Products (Inc.) 54
*Peabody Engineering Corp. 61
Permutit Co. 3rd Cover
Philadelphia Gear Works 85
Posey Iron Works (Inc.) 26

Research Corp. 46
Revere Copper & Brass (Inc.) 73
Ric-Wil Co. 9
*Robertson, John, Co. 97
Rockford Clutch Div. of Borg-Warner Corp. 84
*Roots-Connersville Blower Corp. 37

*SKF Industries (Inc.) 8
*Sarco Co. 94
Smith, Winfield H., Corp. 43
Smooth-On Mfg. Co. 64
Sponge Rubber Products Co. 65
Standard Pressed Steel Co. 44, 94
Stuart, D. A., Oil Co. 54

*Taylor Forge & Pipe Works 13
*Taylor Instrument Cos. 24
*Terry Steam Turbine Co. 82
Thomas Flexible Coupling Co. 56
*Timken Roller Bearing Co. 4th Cover

U. S. Electrical Motors (Inc.) 17, 18

*Voss, J. H. H., Co. 44

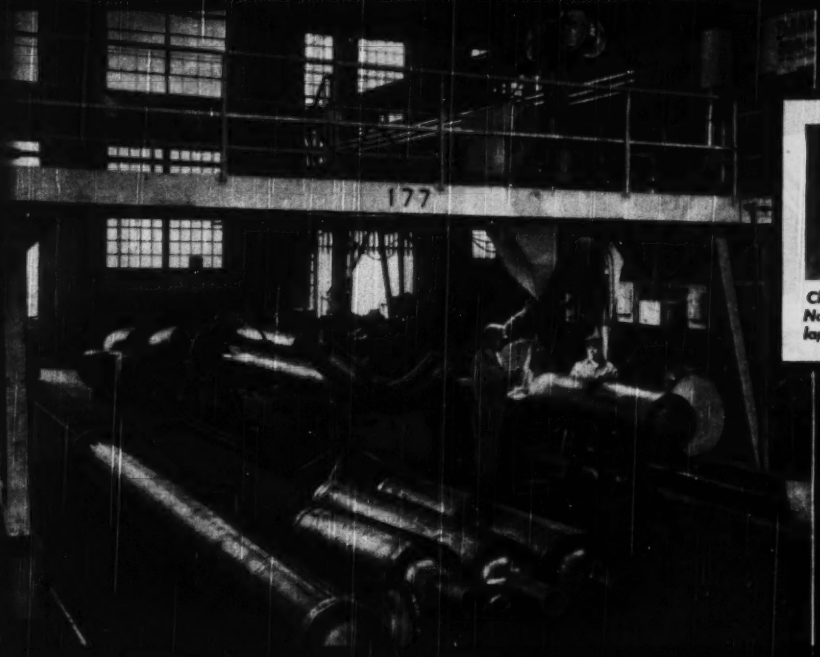
Walworth Co. 78
White, S. S., Industrial Div., S. S. White Dental Mfg. Co. 42
Wisconsin Motor Corp. 51
Wolverine Tube Div., Calumet & Hecla Consolidated Copper Co. 23
Wood's, T. B., Sons Co. 84

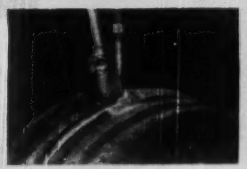
*Yarnall-Waring Co. 35

ENGINEERING SERVICE

Black & Veatch 98
Brown Engineering Co. 98
Buchsbaum, M., Design Consultants (Inc.) 98
Carlson Co. 98
Hathaway, C. M. 98
Lancaster, Allwine & Rommel 98
Ledermann, Frank 98
Myers & Addington 98
National Weld Testing Bureau 98
New York Testing Labs 98
Philadelphia Testing Labs. 98
Polachek, Z. H. 98
Sanderson & Porter 98
Sargent & Lundy 98
Stanley Engineering Co. 98
Tour, Sam & Co. 98
Zust, Charles M., Co. 98

PREFABRICATED PIPING IS IMPROVED

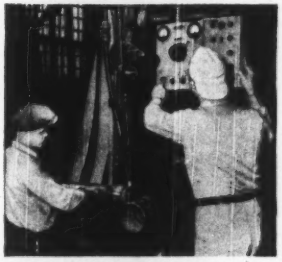




Closeup of the weld being laid. Note smoothness of the overlapping beads.

Movable bridge transports welding head and equipment over the various work rotating machines. Operator is shown adjusting flow of flux that submerges the arc; helper cleans weld with chipping hammer as it rotates past him.

by MIDWEST MACHINE WELDING



Operator stops machine at completion of weld by simply pressing button. Push button controls position welding head exactly over work clamped in rotating machine.

Better welding is assured by this Midwest development because the "human element" has been eliminated for all practical purposes. Aside from work positioning, the operator simply starts and stops the machine; his helper chips off the slag . . . all else is automatic.

Quality of the weld is improved because the machine follows the predetermined procedure *exactly . . . everytime.* The puddle is larger and the arc is better shielded and controlled. The possibility of locking up slag is minimized while undercutting is practically impossible. The greater number of beads is a further improvement.

This application equipment, developed and built by Midwest for use in its own fabricating plants, is representative of the modern facilities used by Midwest to assure better piping.

3477

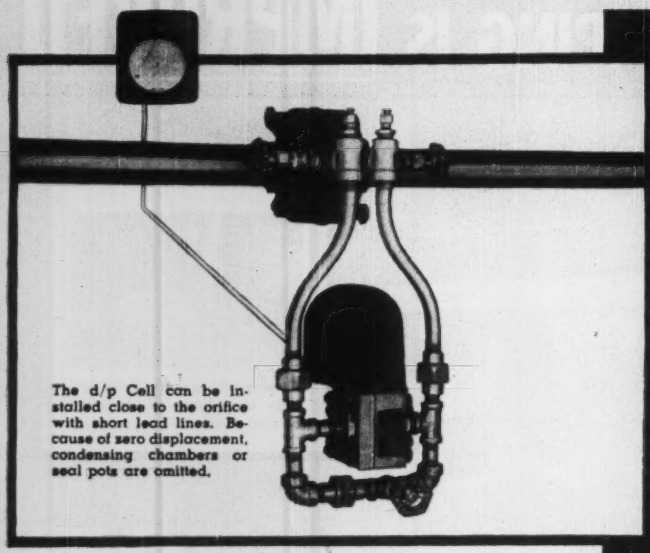
MIDWEST PIPING & SUPPLY COMPANY, INC.

Main Office: 1450 South Second Street, St. Louis 4, Mo.

Plants: St. Louis, Passaic, Los Angeles and South Boston • Sales Offices: New York 7—30 Church St. • Chicago 3—79 West Monroe St. • Los Angeles 33—520 Anderson St. • Houston 2—229 Shell Bldg. • Tulsa 3—533 Mayo Bldg. • South Boston 27—426 First St.

PIPING FABRICATORS AND CONTRACTORS

4 PLANTS ARE BETTER THAN 1



The d/p Cell can be installed close to the orifice with short lead lines. Because of zero displacement, condensing chambers or seal pots are omitted.

Simpler Flow Measurement

in the palm of your hand

NEW • REVOLUTIONARY • MERCURY-LESS

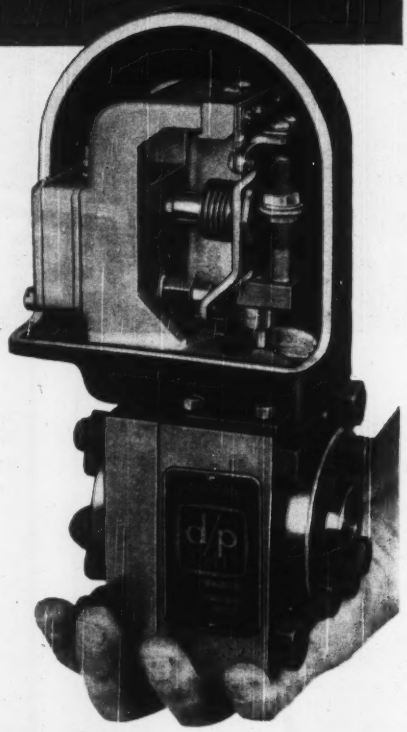
FOXBORO

DIFFERENTIAL PRESSURE CELL

Now you can simplify many troublesome flow problems . . . especially those where corrosion is a factor or the use of mercury is objectionable. This unique flow measuring device is accurate, easily calibrated, and widely applicable, and it weighs only 20 lbs. The Foxboro d/p Cell offers a combination of advantages that no other type of flow measurement can duplicate.

The Foxboro d/p Cell operates on the highly-accurate force-balance principle, transmitting flow measurement to remote, conveniently-located pneumatic receiving instruments (indicating, recording, controlling). Range: 100 in. to 800 in. H_2O. Working pressures: 500 psi and 1500 psi.

Get all the facts about this revolutionary new device for the measurement of liquid, steam, gas or air flow. Write for Bulletin 420. **The Foxboro Company, 182 Neponset Ave., Foxboro, Mass., U. S. A.**

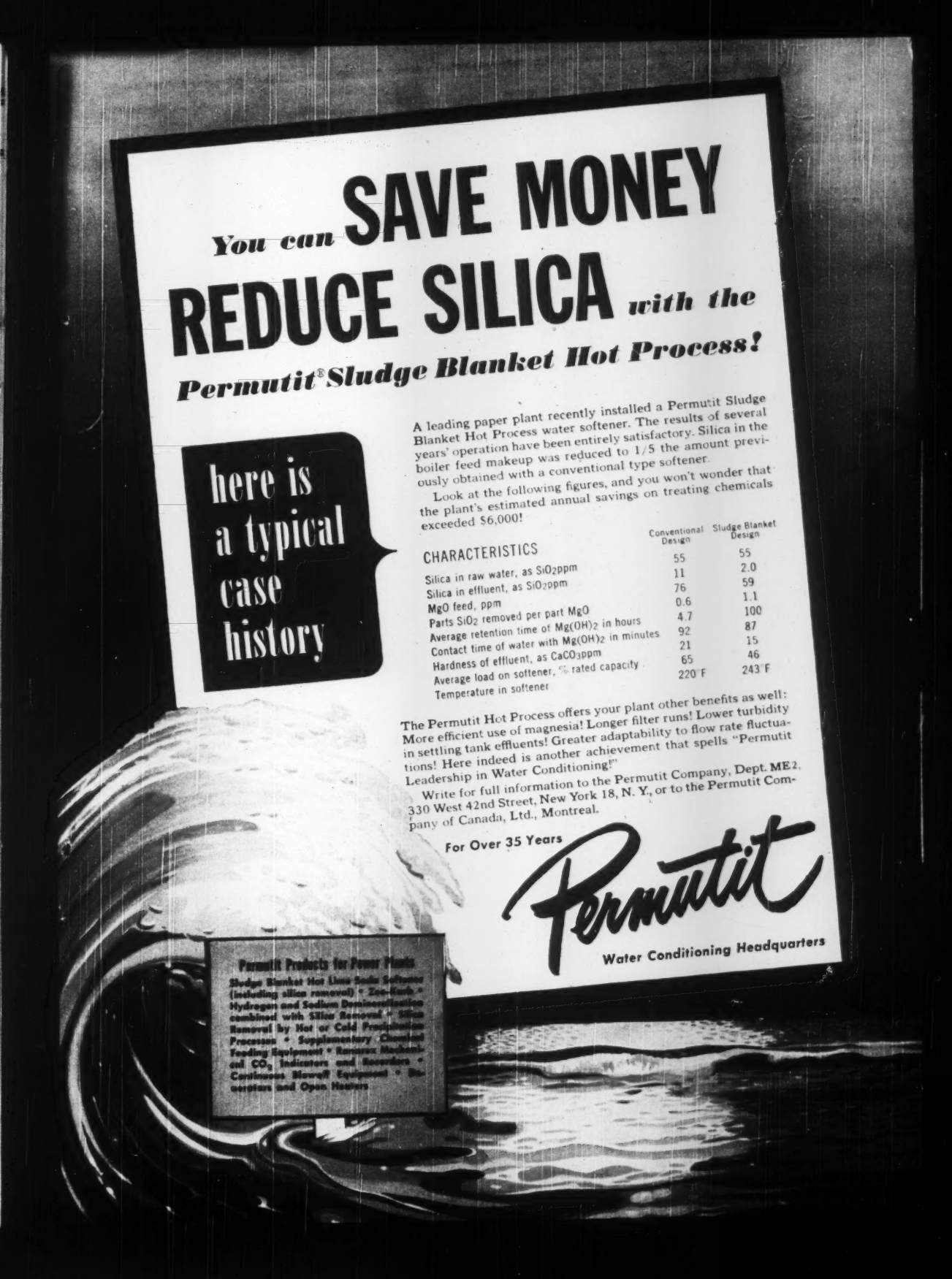


UNIQUE ADVANTAGES

1. Type 316 Stainless Steel Construction.
2. Uses no mercury.
3. Essentially zero displacement—no need for condensing chambers on steam measurement or seal pots on liquid measurement.
4. Immediate, unfailing response to differential pressure changes.
5. Positive overrange protection.
6. Easily changed in the field to *any* range (100" to 800" differential).
7. Simple zero adjustment.

FOXBORO
REG. U. S. PAT. OFF.

RECORDING · CONTROLLING · INDICATING
INSTRUMENTS


You can SAVE MONEY
REDUCE SILICA with the
Permutit® Sludge Blanket Hot Process!
here is a typical case history
A leading paper plant recently installed a Permutit Sludge Blanket Hot Process water softener. The results of several years' operation have been entirely satisfactory. Silica in the boiler feed makeup was reduced to 1/5 the amount previously obtained with a conventional type softener.
Look at the following figures, and you won't wonder that the plant's estimated annual savings on treating chemicals exceeded $6,000!
CHARACTERISTICS
Conventional Design
Sludge Blanket Design
Silica in raw water, as SiO_2 ppm 55 55
Silica in effluent, as SiO_2 ppm 11 2.0
MgO feed, ppm 76 59
Parts SiO_2 removed per part MgO 0.6 1.1
Average retention time of $Mg(OH)_2$ in hours 4.7 100
Contact time of water with $Mg(OH)_2$ in minutes 92 87
Hardness of effluent, as $CaCO_3$ ppm 21 15
Average load on softener, % rated capacity 65 46
Temperature in softener 220°F 243°F
The Permutit Hot Process offers your plant other benefits as well: More efficient use of magnesia! Longer filter runs! Lower turbidity in settling tank effluents! Greater adaptability to flow rate fluctuations! Here indeed is another achievement that spells "Permutit Leadership in Water Conditioning!"
Write for full information to the Permutit Company, Dept. ME2, 330 West 42nd Street, New York 18, N. Y., or to the Permutit Company of Canada, Ltd., Montreal.
For Over 35 Years
Permutit
Water Conditioning Headquarters
Permutit Products for Power Plants
Sludge Blanket Hot Lime-Soda Softeners (including silica removal) • Zeo-Kats • Hydrogen and Sodium Demineralization combined with Silica Removal • Silica Removal by Hot or Cold Precipitation Processes • Supplementary Chemical Feeding Equipment • Ramarex Mechanical and CO_2 Indicators and Recorders • Continuous Blowoff Equipment • Deaerators and Open Heaters

New TIMKEN® "Double-Zero" bearing has twice the accuracy of any TIMKEN bearing ever made!

PRODUCTION BEING INCREASED TO MEET GROWING DEMAND AS "00" BEARING BRINGS NEW PRECISION TO MORE AND MORE PRODUCTS

Twice as accurate as the Timken® "Zero" bearing — previously the most accurate Timken bearing on the market — the new "Double-Zero" bearing offers industry great new opportunities for high precision. Run-out tolerance in the new "Double-Zero" is only 75 millionths of an inch!

This amazingly low run-out has resulted in quick adoption of the "Double-Zero" bearing for lathe spindles, grinding-machine spindles, small precision rolling mills, dividing heads, and gear cutting machines. And production of the "Double-Zero" has been repeatedly upped to meet the growing demand for greater precision.

The extremely high accuracy of the "Double-Zero" bearing has been made possible by The Timken Roller Bearing Company's development of new measuring devices, specialized machine tools, and improved manufacturing methods.

"Double-Zero" sizes and types are shown in the chart below. For more information write The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

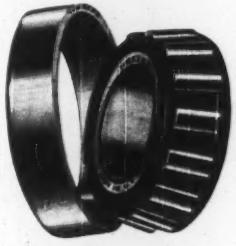
This symbol on a product means its bearings are the best.

A PRECISION TIMKEN BEARING FOR EVERY REQUIREMENT			
CLASS	**"00" (DOUBLE-ZERO)**	**"0" (ZERO)**	**"3" (THREE)**
RUN-OUT	.000075"	.000150"	.000300"
TYPES AVAILABLE	Standard Single Row	Standard Single Row	All types
SIZE RANGE	Up to 10" O.D.	Up to 12" O.D.	Up to 12" O.D.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



NOT JUST A BALL ◯ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⓡ AND THRUST →ⓣ← LOADS OR ANY COMBINATION →✳←